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PARAMETERIZATION OF WEATHER RADAR
DATA FOR USE IN THE PREDICTION
OF STORM MOTION AND DEVELOPMENT

by

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Algorithms were developed for the rapid and efficient representation of digital data from a single Doppler weather radar. The data are processed to obtain a number of attributes which describe small convective cells, larger echo areas, and isolated regions of high tangential shear. The data are also processed to provide estimates of the environmental wind velocity profile and the total reflectivity profile. The attributes are obtained to represent the essential information content of the radar data with the fewest possible number of parameters. The attributes were selected to describe the development and motion

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of severe storms and, in particular, the small convective elements that are viewed as the building blocks of the storm. Attributes were also selected to describe isolated tangential shear maxima to obtain signatures of storm severity.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Program Objective

The ultimate goal of the work reported herein is to develop an objective method for the short range forecast of storm development and motion. The initial step in this program is to devise a set of parameters for the characterization of weather radar data to efficiently represent the essential information obtained by a radar without requiring extensive storage capacity to handle unprocessed data. In this report we consider techniques for the representation of the reflectivity and Doppler velocity fields generated by a single weather radar. The reflectivity data are considered both alone and in conjunction with simultaneously obtained Doppler data.

A computer program was developed to process Doppler weather radar data to obtain the required parameters. The program detects small convective cells and larger echo regions and computes a series of attributes for each. The program represents the first step in the development of an objective procedure for the automatic processing of weather radar data for use in the short range forecast of storm development and motion.

1.2 Summary

The recommended parameterization of radar data is based upon the use of small convective cells to represent the basic architecture of a storm system. Convective cells are readily apparent in isolated showers, clusters of showers, and squall lines. They are also evident as imbedded structures in the rain bands associated with widespread rain. Crane (1976) found that small convective cells were stable entities which could be reliably identified on successive scans and tracked from scan to scan.

The small cells are characterized by a set of attributes: intensity, area, height, age, stage of development, associated low level convergence (radial shear), associated vorticity (tangential shear), and propagation velocity. Additional parameters are obtained to characterize the cells within a larger precipitation (echo) region. These parameters include cell spacings and relative orientation, number of cells within a precip-

itation region, relative cell motion, and the motion of the cells relative to the motion of the centroid of the encompassing echo region. The mean radial velocity data are also processed to estimate the mean wind profile (environmental) and to identify local maxima in tangential shear. The shear maxima may not be coincident with a single cell but may occur within a cell cluster. The location of the shear maxima relative to the location of neighboring cells is also used to characterize the Doppler velocity field.

A previous analysis of available aircraft observations of velocity fluctuations and of radar observations of tangential shear and Doppler velocity variance by Crane (1976) had shown that the velocity variance was primarily caused by shear within the radar sampling volume. The variance data therefore may not be useful for the estimation of the intensity of turbulence as described by an eddy dissipation rate. For this reason, the mean Doppler velocity estimates provide the principal data to be processed. These data are used to develop radial and tangential shear estimates for association with detected cells and to locate tangential shear maxima not associated with a cell. Variance data are used to mark regions with larger than normal velocity fluctuations that should not be included in estimates of the environmental wind. Local maxima in velocity variance are also detected for comparison with the attributes of local maxima in tangential shear to test the hypothesis that the major contribution to the observed variance is due to larger scale shear rather than turbulence.

The data parameterization reduces the amount of data required to represent the initial radar observations. Each volume scan is represented by detected cells, by larger echo regions, by tangential shear maxima, and by the attributes of the cells and larger echo regions. Additional information is provided to describe the spatial organization of the cells. These data will be used in the forecast of cell propagation as defined by their development and motion. The cells and their attributes are important for the identification of severe weather and aircraft hazards, however, they do not represent the total production of precipitation within the echo envelope surrounding the cells. Additional data will be provided to represent the equivalent precipitation depth (accumulation) within a larger echo region.

1.3 Software Development

The goal of this contract with the Air Force Geophysics Laboratory (AFGL) is to provide computer software to obtain the parameters required to represent weather radar data. The radar used to provide the data is the C-band weather radar operated by the Weather Radar Branch of AFGL at Sudbury, Massachusetts. The computer programs were prepared for the CDC-6600 at AFGL.

Table 1 provides a list of the cell and echo area attributes recommended as important for the efficient representation of the radar data. Due to the limited duration of this contract it was not possible to provide software to obtain all the attributes on the list. The attributes identified by asterisks are calculated by the first generation computer program developed under this contract. These attributes describe radar data obtained on a single azimuth scan. Algorithms exist to combine data from a series of azimuth scans within an elevation scan (Crane, 1976) but were not included in the first generation computer program.

Although cell tracking algorithms are also available (Crane, 1976) they were not included in the first generation program package. The development and fine tuning of the tracking algorithms require experience with the cell detection program under a number of different environmental conditions such as isolated showers, squall lines, and widespread rain. Neither the data nor the time were available to process the required data.

1.4 Organization of the Report

A review of radar data processing is given in Section 2. Reflectivity-based parameters are discussed in Section 3. The use of Doppler data is considered in Section 4. The computer algorithms, a description of the software package and sample results are given in Section 5. Section 6 summarizes the results obtained to date.

TABLE 1

CELL, TANGENTIAL SHEAR, AND LARGER ECHO AREA ATTRIBUTES

Small Convective Cells	Tangential Shear Maxima	Larger Echo Areas
Peak Intensity*	Intensity (Profile)*	Average Intensity (Profile)*
Average Intensity (Profile)*	Area (Profile)*	Environmental Wind (Profile)*
Area (Profile)*	Centroid Location*	Centroid Location*
Volume	Height	Area (Profile)*
Height	Tilt	Total Reflectivity Profile*
Height of Maximum Reflectivity	Age	Centroid Motion
Height of Cell Base	Centroid Velocity	Structure of Enclosed Cells
Height of First Echo	Rate of Development	Number
Centroid Location*		Location
Cell Tilt		Orientation
Average Radial Shear*		Structure of Enclosed Tangential
Average Tangential Shear*		Shear Maxima
Average Radial Velocity*		Number
Age		Location
Centroid Velocity		Orientation
Rate of Vertical Development		Precipitation Accumulation*

*Attributes Provided by First Generation Computer Program

2. BACKGROUND

Although weather radar data have been operationally available for many years, they have not been used in routine objective forecast procedures. Weather radar data were initially displayed as echo-filled or echo-free regions on a plan position indicator (PPI) display. The data displays were useful in locating precipitation regions and providing forecast verification, but they were not useful for measuring storm intensity or displaying the structure of the storm. Next, reflectivity data were depicted using fixed level contours. These contours provided a graphic display of storm intensity and structure but unfortunately only a limited number of contours could be displayed and interpreted. Recently, the use of color displays has increased the number of contours that can be displayed. Operator interpretation is still difficult and the data require additional processing before they are available for quantitative objective analysis.

Digitized radar data are required for objective analysis. Most current research radars obtain and store the radar data in a digital form, and operational systems are being improved to provide digital data. Attempts have been made to use digitized fixed contour level data for the objective forecast of storm motion. Recently, Elvander (1976) reported on the performance evaluation of three different techniques to estimate and forecast echo motion. The first (oldest) technique used a linear least squares tracking procedure to follow the centroids of echos defined using a fixed reflectivity level contour (Barclay and Wilk, 1970; Wilk and Gray, 1970). The predicted location of an echo region was estimated by extrapolation along a least square curve fit to the previously observed echo locations. This procedure can not handle storm development, growth, or decay - only storm translation.

The other two tracking techniques used echo velocity estimates based upon correlation analysis. Correlation analyses have been used for years to study echo characteristics and their changes (see for example Kessler and Russo, 1963). Recently, two separate correlation procedures were tried to automatically derive storm motions: correlations involving only isolated echo regions (Duda and Blackmer, 1972; Blackmer et al. 1973) and correlations using the entire PPI display

(Austin and Bellon, 1974). The first provides independent velocity estimates for each echo region; the latter uses a single velocity for all the depicted echo areas. Crane (1976) found that the echo areas propagate to encompass the growth and decay of small enclosed convective cells. The small cells have regular tracks but cells within a larger, isolated echo region may move in slightly different directions. The motions of the larger echo regions were erratic as they merged, separated, and changed to encompass the developing cells.

Elvander found that the objective procedures that forecast the motion of echo centroids defined using the lowest level reflectivity data worked best when based upon velocity estimates generated using correlation techniques. He reported that the least squares curve fit approach worked best when the echo centroids were defined using vertically integrated liquid water content (VIL) data. Since the VIL values are largest within the small active regions of convection, the VIL results should be similar to those reported by Crane (1976) when the echo regions are dominated by a single intense cell. The National Hurricane and Experimental Meteorology Laboratory has also been experimenting with objective echo identification and tracking procedures (Östlund, 1974; Wiggert et al, 1976). They initially used the echo centroid tracking procedure but have recently abandoned that technique to use a procedure that tracks reflectivity maxima or peaks. The locations of the peaks (reflectivity maxima) are found by best fitting (correlating) the observed reflectivity values with a number of two-dimensional Gaussian distributions. The best fit Gaussian distributions are used to identify the peaks within an echo to be tracked. This procedure was devised to improve the operation of their program when splits or merges occur.

An alternative development in the representation of reflectivity maxima or peaks within a larger echo region is the use of small cells defined by contours a fixed level below local reflectivity maxima within larger echo regions (Crane, 1976). These cells are defined by small reflectivity changes and correspond to volumes that encompass updraft regions during the growth stage of cell development and encompass downdraft regions during the mature stage. They are defined on a single scan by local reflectivity maxima only a few dB above their surroundings. The local concentrations of liquid water are reliably detected throughout

the active stages of cell development. Single identifiable regions of locally increased liquid water content persist from scan to scan for durations of 5 to 50 minutes. The small cells are continuous in height and display smooth regular horizontal motion.

Doppler velocity observations show that the small active cells are important elements in organizing deviations in the flow field from that of the surrounding or environmental flow pattern. Reported Doppler velocity measurements show little deviation from the environmental or background winds over much of the volume enclosed within an echo region. Doppler velocity observations near the small cells reveal the convergence patterns required to feed the updrafts and respond to downdrafts. The data also reveal mesoscale cyclones (and anticyclones) associated with the updraft regions and with secondary flows caused by a number of closely spaced cells.

Currently, the analysis of single Doppler radar data is based upon comparison with simplified kinematic models for the flow fields of importance to severe weather: supercells, tornadoes and low level gust fronts (Donaldson, 1970; Browning and Foote, 1976; Burgess, 1976; Brown and Lemon, 1976; Zrnic et al, 1976). The identification of regions of severe weather is made by comparing the Doppler observations with signatures representative of each of the models. The Doppler data provide a measure of the severity of the weather associated with features of the reflectivity field. The reflectivity data in turn provide the means to forecast the motion of the active regions that are probable sites of severe weather.

Doppler data have been mainly used for the display of the flow fields within an echo region (especially multiple Doppler radar data) and for the identification of severe weather. They have not been used in an objective fashion to forecast the motion of severe weather. Initially, in the objective analysis algorithms developed under this contract, the reflectivity data are to be used to identify cells and, using observations on successive scans, their motion. The Doppler data will be used for the identification of regions of severe weather or possible hazard. The data will be processed in a manner to allow ready incorporation of additional features of either the Doppler or reflectivity fields that appear to be important after detailed analysis of a large set of data using the initial processing algorithms.

3. OBJECTIVE ANALYSIS OF REFLECTIVITY DATA

Objective analysis of reflectivity data must provide information for use in forecasting the location and development of severe weather and for use in measuring the production of precipitation and the resultant distribution of precipitation on the ground. The analysis algorithms developed under this contract include two types, (1) the small cell analysis using peak reflectivity reference contour levels, and (2) larger echo area analysis using fixed echo contours. The former is recommended because of the association between convectively active regions and severe weather and because of the utility of the small cells for the forecast of pattern development and motion. The latter is recommended to keep track of the precipitation produced by the active cells. No attempt will be made to partition the precipitation within an echo region by cell.

3.1 Small Cells

The use of objective techniques for the detection of small convective cells was developed and reported by Crane (1976). He found that a small cell can be readily detected using at most three azimuth scans; the detection probability for a single scan was above 0.6 for the reflectivities greater than 35 dBZ and for three scans in a volume scan sequence, the probability of detection increases to 0.93. The detection probability is still higher for a typical volume scan with a larger number of azimuth scans at different elevation angles.

The small cell detection procedure developed by Crane is illustrated in Figures 1 and 2. Figure 1 shows a hypothetical echo region (lowest level contour) including two cells. The cells are identified by smaller contours T* units below their enclosed relative maxima. The cell areas are the shaded regions within the peak referenced contours. Figure 2 shows the application of this detection process to actual radar data using a 2.5 dB value for T. The outer or lowest level contours on this figure have a value of 20 dBZ. The peak values are above 50 dBZ. The data reveal a wealth of detail not evident using a limited number of fixed level contours separated by large differences in reflectivity. The display as shown in Figure 2 is quite complex. It may be replaced by the

*T represents the cell detection threshold.

display in Figure 3 with little loss of information. On this figure the cell attribute, peak reflectivity, is listed for each cell. Other attributes such as cell area, cell height, height of maximum reflectivity, height of cell base for first echo, or any other measurable associated with the reflectivity of Doppler data fields may be calculated and displayed or recorded for each of the cells.

3.2 Larger Echo Areas

The small cells are generally contained in larger multicell echo regions. Warner (1976) reported that all the hailstorms he observed in Alberta, Canada occurred as small cells within larger echo areas. An analysis of his reported data shows that single isolated cells do not develop significantly either in height or intensity. Clusters of cells within a single envelope defined by a low level reflectivity contour (10-20 dBZ) usually exhibit more significant development growing both higher and more intense than the single isolated cells that appeared at the same time on the same day.

The apparent cooperation between small closely spaced cells has been reported by other investigators. Woodley and Simpson (1972) have reported that convective cells in the Florida area have a higher intensity and produce more precipitation after they merge than before. They declare mergers when echo regions defined by a fixed 25 dBZ contour combine to form a larger multicell echo region. Their data show that the environment surrounding each cell is important. The number, spacing, and relative orientation of the cells within a single echo region appear to affect the development of the small cells. These data must be recorded in addition to the attributes of each cell. They are attributes of the larger echo region.

The small cells are considered to be the active regions of convection within the larger echo region. The larger area encompasses precipitation resulting from the transport of liquid water (and ice or snow) and water vapor out from the updraft regions. The transport processes are mainly turbulent - eddy diffusion or advection depending upon the scale size of the motion. Microphysical processes continue to produce precipitation within the larger regions about each cell which results in precipitation that is measurable on the ground. The precipitation is

apparently carried out from the cells by the environmental or background winds as it settles to the ground. The larger echo area also contains the decaying cells that remain after their active stages have been completed. The total precipitation in this region is important and must be obtained from the radar data. The transport processes are complex and it does not appear reasonable to attempt to identify the resultant precipitation with particular active generating regions.

At midlatitudes the larger area of precipitation surrounding the active cells generally consists of ice and snow aloft melting to form rain below. Care must be taken in processing the data to exclude measurements made within the melting region or bright band. Data taken at the lowest elevation angle will be processed once per volume scan to provide an estimate of the rain rate integrated over the area of the larger echo region. Rain rate estimates made on a series of scans (lowest elevation from each volume scan) will be combined to estimate the averaged accumulation of precipitation at the surface.

4. OBJECTIVE ANALYSIS OF DOPPLER DATA

A single radar system can only measure the radial velocity of the scatterers relative to the radar. This component of the scatterer motion is not sufficient to characterize the three-dimensional motion of the scatterers within the sampling volume defined by a range resolution element times the antenna beam cross section. Models must be employed to extract useful data from the Doppler velocity estimates. If a radar were completely surrounded by scatterers all moving in the same direction, the particle velocity could be measured by making observations in three different directions (including vertical for three-dimensional motion). Unfortunately, the scatterers are not all moving in the same direction especially in the vicinity of the small active cells.

4.1 Velocity Information Associated with a Small Cell

The flow field about and within a small cell is too complex to be measured with a single Doppler radar. Shear values can be calculated for the area within the cell to characterize the variation of the flow field within that cell. For a simple axisymmetric flow pattern model with a vertical symmetry axis radial shear values can be identified with convergence and tangential shear values with vorticity if measurements are made at a low elevation angle. The success of the plan shear indicator (Donaldson, 1970) and the use of the mesocyclone signature (Burgess, 1976) and the tornado vortex signature (Brown and Lemon, 1976) are based upon this model for the flow field. In general, the flow pattern is not axisymmetric and larger scale shear deforms the simple model flow causing a more complex pattern. The deviations from the model appear to be small and the model seems to be useful for identifying potential regions for the development of tornadoes. For this application the average shear values within a cell are of interest.

Detailed reflectivity and Doppler velocity measurements in situations characterized by supercells and tornadoes reveal mesoscale circulation patterns not within the confines of a small cell. (See the Stillwater tornado data reported by Zrnic et al, 1976 and discussed in Section 6.1; see also Agee et al, 1976.) The circulation about a weak echo region

appears to be associated with a secondary circulation caused by the cells neighboring the weak echo or echo-free vault. The mechanism for triggering and maintaining the circulation is uncertain. It is evident that a tangential shear signature occurs that is not within a cell. This region can be separately identified using Doppler velocity data.

4.2 Mean Velocity Within a Larger Echo Region

The lower reflectivity regions surrounding the small, active cells generally follow the environmental wind. Velocity measurements made in the lower reflectivity regions may be used to estimate the environmental wind. Observations must be made at the same range and at least at two different azimuth angles. An estimate can be generated by assuming that the wind at a given height (range) is constant over the azimuth span of each echo region. The velocity is calculated using a least squares procedure on all data not included in detected cells and in regions with high velocity variance.

4.3 Turbulence Estimates

Analysis of aircraft observations of wind velocity fluctuations within thundershowers show that the turbulence is anisotropic at scale sizes in excess of 200 meters and suggest that velocity variance measurements at scale sizes larger than 200 m will not describe the turbulent dissipation process (Crane, 1976). The doppler velocity fluctuations are caused primarily by radial velocity fluctuations at scale sizes the order of the antenna beam cross section at the measurement range. For most radar systems, the scale sizes associated with Doppler measurements are in the 1 to 3 km range, significantly outside the range for isotropic turbulence. The variance estimates therefore correspond to larger scale processes such as organized up and downdrafts and their associated convergence and rotation patterns, for example, mesocyclones. The radial wind speed profile however does not vary linearly across the radar beam and simple models to estimate variance due to shear will lead to large measurement errors. Errors in a simple linear model or any other model for the variation of wind speed across the beam will cause insufficient estimation accuracy to remove the effect of shear and leave an accurately estimated residual component.

Pulse-volume to pulse-volume changes in the mean Doppler velocity will be used to estimate shear because the Doppler variance estimates should be identified with shear and because the variance estimates tend to be biased and severely affected by noise. The radial velocity variations within the beam that contribute to the observed variance may be associated with either vertical or horizontal variations in the wind field. Mean Doppler velocity observations may be used to estimate the horizontal variations evident after averaging by the antenna beam. Comparisons should be made between tangential shear and velocity variance data to determine the degree to which the larger scale horizontal shear contributes to the variance. If significant variance can occur in regions where the tangential shear is low, relative variance maxima attributes could also be used to characterize the radar data.

5. SOFTWARE DESCRIPTION

5.1 Program Structure

The object of this contract was to develop a set of algorithms for the processing of single Doppler radar data and to provide a computer program to accomplish the data processing. The cell detection procedure selected for this task is based upon a procedure previously developed by Crane (1976). The algorithms developed under this contract are significantly different from the earlier ones used by Crane or from the contouring algorithms generally used on large scale computers. The new algorithms were developed specifically for this contract to provide rapid computer processing requiring a minimum of computer storage. The algorithms were also generated to simultaneously process both reflectivity and Doppler data in a manner constant with ultimate employment in real-time programs on a mini-computer coupled to a weather radar.

The computer program processes the digital radar data and generates the cell and larger echo area attributes identified by asterisks in Table 1. The program was designed to read digital radar data tapes prepared by the Weather Radar Branch of AFGL at their Sudbury field station. The raw data consisted of received power, mean radial velocity, and velocity variance values together with radar operating and pointing parameters plus time as described by the input data format given in Appendix A. A series of subroutines were developed to read and reformat the radar data, find both fixed and peak referenced contours, and calculate the attributes associated with the contours. A schematic of the program is given in Figure 4. The program provides contour output data for input to a second program which generates plots for fixed level contours, and outputs attributes calculated for the small convective cells, tangential shear maxima, and fixed echo regions.

This program is configured to be the first in a series of programs that (1) detect the cells and generate the lists of attributes; (2) combine data from separate scans within a volume scan to provide the vertical development attributes for the detected cells, tangential shear maxima, and fixed contours; and (3) combine data from separate volume scans to generate cell tracks and to list the time histories of the cells. A schematic overview of the entire processing sequence is given in Figure 5.

The computer program listing is reproduced in Appendix B; the operating instructions are in Appendix A.

5.2 Contour Generation Algorithm

The contouring algorithm used to find both the fixed level contours and the peak referenced contours was designed to process the radar data a single radial (all data for a single pointing angle) at a time. The processing algorithm was tailored after the technique generally used to obtain isoecho contours for a weather radar display and is significantly different from the edge following algorithms generally used in computer processing. The edge following contouring algorithm requires the storage of the entire data field in the main computer memory at one time. For the radar data to be processed, the reflectivity data alone would require 184,320 storage locations which exceeds the available core storage if not packed into the CDC 6600 computer words. If the data were packed, considerable time would be expended unpacking the data for use with the contouring algorithm. This new approach was taken to minimize both the computer storage and time requirements. The processing is performed in the range, azimuth coordinates of the radar. The program searches the data in range along a radial defining regions or events where the data exceed the thresholds for contouring. For fixed level contouring, the thresholds are preselected; for peak reference contouring, the thresholds are computed from the data. This contouring algorithm differs from the usual application of isoecho contouring techniques by combining data for each event from one radial to the next to generate the attributes. The peak detection algorithm is unique since it stores sufficient data from radial-to-radial to obtain the required attributes even though the threshold level is not known apriori.

The contouring operation starts by searching the data along a single radial. The start and stop ranges for each event are defined by threshold crossings as illustrated in Figure 6. The data are quantized prior to contouring and the thresholds are applied just above the reported value. For example, a 20 dBZ threshold would include only data that exceeded 20 dBZ. Since a round-up operation is included in the generation of the quantized data, a 20 dBZ threshold would include all values above 20.5 dBZ. The data are searched by threshold at each range element reducing

the number of tests applied at each range element to a minimum. The event identification algorithm is depicted by the flow chart on Figure 7. In the remainder of the processing, only data within an event are tested or combined with other data to generate attributes.

The data for events from one radial are combined with data from events for the previous radial to calculate the attributes. This process is illustrated schematically on Figure 8. Events on both radials are searched to locate adjacent events. If more than one B event (previous radial) overlaps a single C-event (current or this radial) then the attributes for both B-events are combined into a single set. Each identifiable echo region is tagged by an identification number which is used to index the final set of attributes.

The attributes are processed separately for each threshold. Additional processing is performed for the lowest level threshold. Each separate identifiable peak along each radial is located and recorded for subsequent use in the peak reference contouring subroutine. The height of each range element within each lowest threshold event is calculated and then used to index arrays for accumulating reflectivity and velocity data as a function of height. These data are used for the generation of reflectivity and environmental wind profiles.

The peak reference contour algorithms are identical with those described above with the exception that the contouring thresholds are separately calculated for each radial. The peak detection algorithm uses a threshold a fixed number of quantization steps below the peak value. Since the peak value is not known apriori, attributes must be summed for each possible cell (segment of radial) within the fixed number of steps below each peak value. The data are processed one event (lowest fixed level threshold) at a time. Threshold levels are established for each peak within the event. The data at each threshold level are associated between the B- and C-radial segments. Cells are declared when cells have been detected which do not enclose other cells at a threshold level the required fixed number of steps below the peak value. When B- and C-radial data are associated, the highest peak from either B- or C- is taken as the new peak and athe attributes are restored so only data for the required fixed number of steps below each peak are saved. This process is repeated from one radial to the next until a cell is not

updated and no higher level data are present on the next radial adjacent to the cell. At this point, a peak referenced cell has been detected. Only the attributes for the lowest saved threshold relative to the peak are then saved for subsequent processing. To ensure that a second cell immediately adjacent to a previously detected cell is not subsequently detected, the C-radial segments are also compared with B-radial data and attributes for a threshold are saved only when the C-radial data are of higher value or a B-radial cell is being activity processed. The peak detection process is illustrated schematically in Figure 9.

5.3 Attributes

The area, average reflectivity, and centroid location are calculated for each fixed contour echo region and for the contour a prescribed number of quantization units (CDB) below each peak value. The basic data were obtained in a polar coordinate system. The attributes are calculated as follows when the sums are taken over all i (range), and j (azimuth) enclosed within the contoured region:

$$A = \sum_{i,j} (\theta_j - \theta_{j-1}) r_i \Delta r$$

$$\overline{Z} = \frac{1}{A} \sum_{i,j} (\theta_j - \theta_{j-1}) r_i Z_{ij} \Delta r$$

$$\overline{x} = \frac{1}{A\overline{Z}} \sum_{i,j} (\theta_j - \theta_{j-1}) r_i^2 \sin\theta_j Z_{ij} \Delta r$$

$$\overline{y} = \frac{1}{A\overline{Z}} \sum_{i,j} (\theta_j - \theta_{j-1}) r_i^2 \cos\theta_j Z_{ij} \Delta r$$

where A is the area, $\overline{Z}$ is the average of the logarithm of reflectivity, $\overline{x}$, $\overline{y}$ are the rectangular coordinates of the centroid, θ_j is the azimuth angle, r_i is range, Δr is the range interval, and Z_{ij} is the logarithm of the reflectivity value (in dBZ). For the detection of localized tangential shear maxima, the logarithm of the reflectivity value is replaced by

$$VS_{ij} = (V_{ij} - V_{ij-1})/(r_i(\theta_j - \theta_{j-1}))$$

where VS_{ij} is the tangential shear and V_{ij} is the mean radial velocity.

Additional shear attributes are calculated for the peak reflectivity referenced attributes. These were the average radial shear

$$\overline{VR} = \frac{1}{A} \sum_{i,j} (\theta_j - \theta_{j-1}) r_i (V_{ij} - V_{ij-1})$$

the average tangential shear

$$\overline{VS} = \frac{1}{A} \sum_{i,j} (\theta_j - \theta_{j-1}) r_i VS_{ij} \Delta r$$

and the average radial velocity

$$\overline{V} = \frac{1}{A} \sum_{i,j} (\theta_j - \theta_{j-1}) r_i V_{ij} \Delta r$$

The fixed contour profiles are calculated by summing the required attributes for height regions quantized in 1 kilometer steps. The height is computed using

$$H_i = r_i \sin\alpha + \frac{r_i^2 \cos^2\alpha}{aR}$$

where α is the elevation angle, R the radius of the earth and a the effective earth's radius multiplier. A value of 1.21 was used for a. In addition the environmental wind velocity profile is statistically calculated using mean radial velocity data confined to a narrow reflectivity interval (typically 20 to 35 dBZ) and for sampling elements with velocity variance values below a preset threshold, TS. The mean easterly and northerly velocities $\overline{u}$, $\overline{v}$ are calculated as follows:

$$\overline{u}(H) = [(\sum_{i,j} \cos^2\theta_j)(\sum_{i,j} V_{ij} \sin\theta_j) - (\sum_{i,j} \sin\theta_i \cos\theta_i)(\Sigma V_{ij} \cos\theta_i)]/DEL$$

$$\overline{v}(H) = [(\sum_{ij} \sin^2\theta_i)(\Sigma V_{ij} \cos\theta_j) - (\sum_{ij} \sin\theta_j \cos\theta_j)(\sum_{ij} V_{ij} \sin\theta_j)]/DEL$$

$$DEL = (\sum_{ij} \sin^2\theta_j)(\sum_{ij} \cos^2\theta_j) - (\sum_{ij} \sin\theta_j \cos\theta_j)^2$$

where V_{ij} is the mean radial velocity and the summations were again taken only over the area within an event (identifiable larger echo region).

5.4 Sample Results

Processing for the C-band Doppler radar at the AFGL Weather Radar Branch in Sudbury was accomplished using 512 range intervals of 300 m

each. The raw data were averaged to reduce the original 1024 range elements to the final 512 value. The processing program is flexible in adjusting to the angular increment between radials. For the data from Sudbury, the interval is roughly 1°. If the entire 360 by 512 data array were stored for both reflectivity and mean radial velocity, 368,764 words of core storage would be required, roughly four times the 106,000 words available on the CDC-6600 computer at AFGL. The computer program described above performs the required contouring and attribute generation operations within the core storage available on the computer and also provides computer generated plots of the fixed level contours and the centroid locations of the detected cells.

The operation of the fixed contour and peak detection algorithms can be summarized by the following synthetic example. The data to be contoured are given in Figure 10. For this example, the threshold for fixed contouring is a value of 0; all numbers shown are within the fixed contour. Table 2 depicts the values for the start and stop ranges (I), the event number and the echo area identifier that is determined after B-radial, C-radial association. In this example, all the data are for one echo area or region although as many as 3 events are detected on a single radial. The number of peaks and their locations within an event are also listed. Each column corresponds to an array in the program; their function is explained in the description of the contouring algorithm (Section 5.2).

The operation of the peak detection algorithm is summarized by the entries in Table 3. The azimuth and event values are the same as for Table 2. The thresholds generated for each of the peaks as well as the segment start and stop locations and associations as possible cells and detected cells are listed. Note that the start locations are of the range element preceding the threshold crossing as are the stop locations. The cells detected by the algorithm are indicated by the solid lines in Figure 10. In many cases, a zero is listed in the possible counter column. In these cases, no cell attribute updating takes place. A cell is detected when a cell is not updated on the current or C-radial and no higher adjacent values are present on the C-radial.

Program operation to date has been to debug and evaluate the operation of the new algorithms developed for the fixed contouring and peak detection

TABLE 2

FIXED CONTOUR TL = 0 (1 & Higher Included Within the Threshold)

Azimuth J	Events IE	Start I	Stop I	Event Counter	No. of Peaks	Peak Location (1)	(2)	(3)	(4)	Echo Area Identifier	
1	1	4	6	1	1	6				1	Set Edge Indicator
1	2	9	12	2	1	11				2	Set Edge Indicator
2	1	3	6	1	1	5				1	
2	2	10	12	2	1	12				2	
3	1	2	5	1	1	4				1	
3	2	9	13	2	1	12				2	
4	1	3	6	1	1	5				1	
4	2	11	13	2	1	12				2	
5	1	4	7	1	1	6				1	
5	2	11	12	2	1	12				2	
6	1	3	11	1	3	4	6	10		1	2 included in 1
7	1	4	7	1	1	6				1	
7	2	8	11	2	1	10				1	
8	1	6	10	1	1	7				1	
8	2	12	13	2	1	13				3	
9	1	5	6	1	1	6				1	
9	2	7	9	2	1	8				1	
9	3	10	12	3	1	12				1	3 included in 1
10	1	2	5	1	1	4				1	
10	2	7	15	2	4	9	11	13	15	1	
11	1	3	4	1	1	4				1	
11	2	8	15	2	2	11	14			1	
12	1	10	11	1	1	11				1	
12	2	12	14	2	1	14				1	

TABLE 3

PEAK DETECTION LDB = 2

Azimuth J	Event	Threshold Counter	Threshold Value	No. of Peaks	Segment	Start I	Stop I	Possible Counter	Cell Counter	Peak Value	Remarks
1	1	1	0	1	1	4	6	-			No Association on 1st Azimuth
1	2	2	4	1	1	10	11	-			Possible Counter = 0
1	2	1	3	1	1	10	11	-			
2	1	2	1	1	1	4	5	1			
2	1	1	0	1	1	3	6	0			Not Above J = 1 Value
2	2	1	0	1	1	10	12	0			Not Above J = 1 Value
3	1	2	2	1	1	3	4	1			
3	1	1	1	1	1	3	4	1	1	3	
3	2	2	2	1	1	11	12	2			
3	2	1	1	1	1	10	13	2			
4	1	1	0	1	1	3	6	0			Below Threshold on 1
4	2	2	5	1	1	11	12	2			
4	2	1	4	1	1	11	12	2	2	6	
5	1	2	4	1	1	5	6	3			
5	1	1	3	1	1	5	6	3			
5	2	1	0	1	1	11	12	0			Below Threshold on 2
6	1	4	8	1	1	5	6	3			
6	1	3	7	1	1	5	6	3	3	9	
6	1	2	1	1	1	3	4	4			
6	1	2	1	1	2	5	7	0			Too Low for Poss. No. 3
6	1	2	1	1	3	9	10	5			
6	1	1	0	3	1	3	11	0			Too Low for Poss. No. 3

TABLE 3 (continued)

PEAK DETECTION LDB = 2

Azimuth J	Event	Threshold Counter	Threshold Value	No. of Peaks	Segment	Start I	Stop I	Possible Counter	Cell Counter	Peak Value	Remarks
7	1	2	3	1	1	5	6	0			Below Threshold on 3
7	1	1	2	1	1	5	6	0			
7	2	2	3	1	1	9	10	5			
7	2	1	2	1	1	9	10	5	4	4	
8	1	2	2	1	1	6	7	0			Too Low for Cell 3
8	1	1	1	1	1	6	7	0			
8	-	-	-	-	-	-	-	-	-	-	Cell 4 Detected, No Seg.
8	2	2	1	1	1	12	13	6			
8	2	1	0	1	1	12	13	6			
9	1	1	0	1	1	5	6	0			Adj. to Poss. Cell = 0
9	2	2	1	1	1	7	8	0			Adj. to Poss. Cell = 0
9	2	1	0	1	1	7	9	0			Adj. to Poss. Cell = 0
9	3	2	1	1	1	11	12	6			
9	3	1	0	1	1	10	12	0			Adj. to Poss. Cell = 0
10	1	2	1	1	1	3	4	7			
10	1	1	0	1	1	2	5	0			Adj. to Value 1 at I = 6, J = 9
10	2	5	8	1	1	8	9	8			
10	2	4	7	1	1	8	9	8	5	9	
10 10 10	2 2 2	3 3 3	2 2 2	1 1 1	1 2 3	8 10 12	9 11 13	0 6 9			Too Low for Poss Cell = 8
10	2	2	1	1	1	8	9	0			Included in 6 at Threshold = 1
10	2	2	1	1	2	10	11	6			
10	2	2	1	1	3	12	13	6			9 nested with 6
10	2	2	1	1	4	14	15	10			
10	2	1	0	4	1	7	15	0			

TABLE 3 (continued)

PEAK DETECTION LDB = 2

Azimuth J	Event	Threshold Counter	Threshold Value	No. of Peaks	Segment	Start I	Stop I	Possible Counter	Cell Counter	Peak Value	Remarks
11	1	1	0	1	1	3	4	0			0 Previous Azimuth
11	2	3	5	1	1	13	14	9			
11	2	2	4	1	1	10	11	6			
11	2	2	4	1	1	13	14	9	7	6	
11	2	1	3	1	1	10	11	6	6	5	
11	2	1	3	1	1	12	14	0			
12	1	1	0	1	1	10	11	0			
12	2	1	0	1	1	12	14	0			

operations. The program has been exercised using both a complex ground clutter pattern that severely tests the multithreshold program logic required for peak detection and actual rain data. The Doppler measurements - shear values and average radial velocity values - are all zero for the ground clutter providing a reasonable technique for ground clutter suppression. Sample program outputs for rain are depicted in Figures 11 through 16. Figures 11 and 12 depict the B-Scan printout display available from the program as an option. The data are averaged in range and printed for each azimuth. The solid radial lines on Figure 13 depict the start and stop scan boundaries. Ground clutter is evident at short ranges at many azimuths and regions of rain are evident to the west and north of the radar. Figures 13 and 14 depict 20 dBZ reflectivity contours. The contours in Figure 14 were obtained from the second EXPAND program which allows variable plotting scales. It depicts an expanded view of the region to the south and west of the radar. The fixed contour identification numbers are shown together with dots to indicate centroid location. Finally, the attributes are listed in Figures 15 and 16.

6. SUMMARY OF RESULTS AND RECOMMENDATIONS

6.1 Use of Attributes

The parameters to be estimated using radar volume scans are listed in Table 1. The attributes can be objectively obtained from reflectivity and mean velocity estimates from a pulse-pair processor. The cell detection algorithm was tested by Crane (1976) using a threshold of 3 dB and a precision of 0.5 dB (128 independent samples). A cursory examination of the measurement precision problem suggests that adequate operation could be obtained using a precision of 1 dB (32 independent samples). This problem still must be considered in some detail using live data.

Sample results have been generated using pulse-pair velocity and reflectivity data provided by the National Severe Storms Laboratory (Doviak, 1976). These data were taken with a precision of 2 dB rms. Even though the data are not as precise as desired, the expected relationships between reflectivity and velocity attributes were evident. Figures 17 through 19 depict data from the Stillwater tornado (Zrnic et al, 1976). The reflectivity data on Figure 17 have been simplified by including only two fixed contours and identifying the locations of the small cells. The reflectivity data as provided by Doviak contained only 5 dB interval contours and the true number of cells could exceed the number displayed. The 40 dBZ contour displays a hooked echo although the hook pattern could not be discerned at any other contour level. The Stillwater tornado occurred within the hook. Figure 18 displays the important features of the mean velocity pattern. The cell locations are again displayed on this figure. The highest (positive) and lowest (negative) Doppler velocity contours together with the contour midway between the two are displayed for each shear maxima. The tangential shear values are listed on the figure. The two shear maxima between the 0 and 10 km differential X positions straddled the 20 dBZ contour and are caused by noise and calculations contaminated by using data from regions without scatterers. These shear values are not real and should be ignored. The highest shear value, 0.03 s^{-1}, corresponds to the Stillwater tornado. This value occurs in a weak echo region that does not coincide with a cell but appears between two cells 5 km apart. The other region of high

tangential shear is associated with a gust front near the surface. It is interesting that a new tornado subsequently formed in the rather weak echo region at the point of highest tangential shear along the gust front. Figure 19 displays the regions with rms Doppler velocity fluctuations in excess of 10 m s^{-1} together with the cells and high tangential shear regions. In this figure the data associated with the edge of the echo region has been suppressed.

The data displayed in Figures 17 to 19 show the important details of the reflectivity structure and the associated tangential shear field. Agee et al (1976) recently reported on multiple tornado occurrences within a single mesoscale cyclone which suggest that the tornadoes are more closely associated with the reflectivity maxima that move within the larger scale flow field surrounding the weak echoregion than with the weak echo region. These results indicate that the spatial structure of highly localized tangential shear maxima and possibly associated small convective cells is an important characteristic of severe storms that spawn tornadoes. The computer program developed under this contract provides a means to obtain the significant information from the radar and display it in a form that is easy to interpret.

6.2 Use of Program

The object of this contract was to develop a computer program that would significantly reduce the amount of data required to characterize a set of weather radar observations. The computer program, although designed for use on the CDC-6600 computer was to be easily transferred to smaller, dedicated radar site computers. The program that was developed uses algorithms that minimize computer storage requirements. The inital program uses nearly the full 106,000 words available on the CDC-6600 computer and techniques have already been devised to significantly reduce this requirement without significantly increasing operation time. As currently configured, an operational version of the program can be generated that uses less than 64,000 16-bit words.

To date, program operation has only been to debug and check the program. The processing includes the generation of a considerable amount of intermediate output. Processing runs have taken less than one second of CDC-6600 time per radial. For real time operation with an onsite computer, operate times of less than one third to one sixth this value

are required and should be achieved with available computers. Initial estimates for the time required just to read in, calibrate, and store the radar data for a single radial range between .1 and .2 seconds, a significant fraction of the computer time required for all the processing. Preprocessing of the data to provide range correction and scaling will also be important for reducing the program cycle time to provide a real time capability.

6.3 Recommendations

The program developed under this contract is a first step in the generation of an automatic data processing system for single station Doppler radar data. The program has been subjected only to preliminary analysis to ensure that the computer code is correct and the program operates as designed. Two tasks now remain: (1) evaluate the operation of the program with a large amount of weather radar data and (2) generate the next level programs to track the cells.

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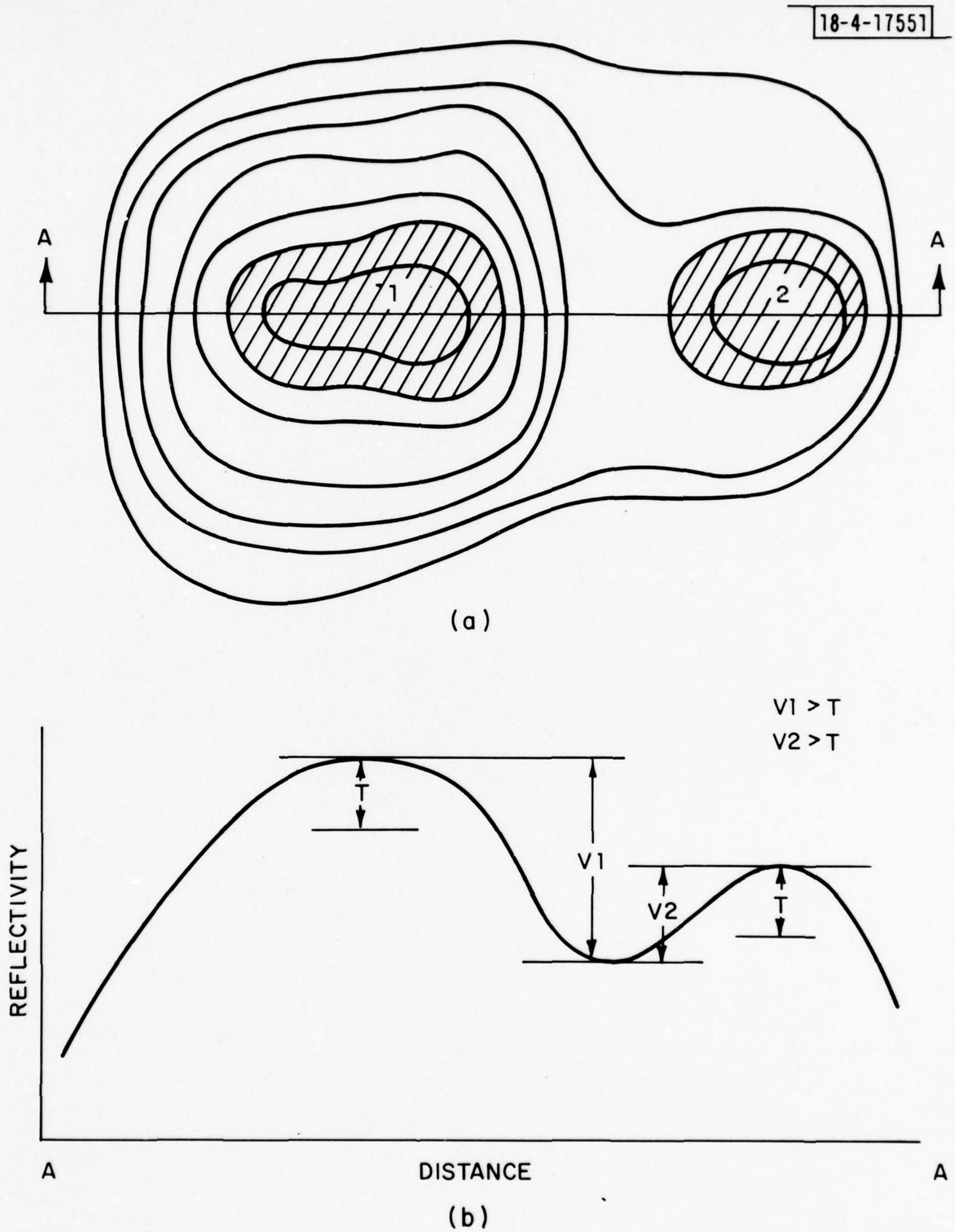

Figure 1 Schematic Illustration of the Cell Detection Criterion (from Crane, 1976)

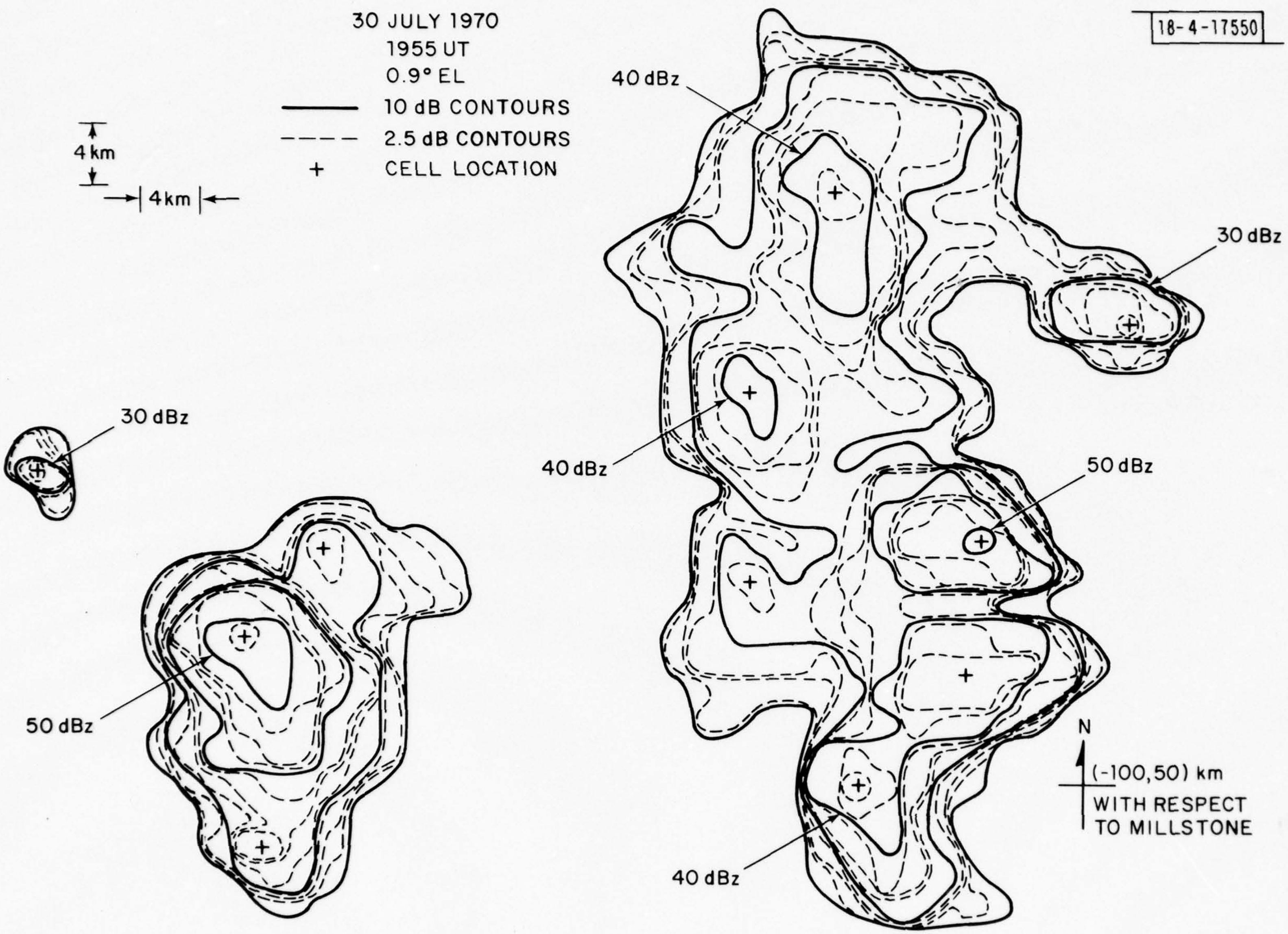

Figure 2 Radar Reflectivity Contours and Cells Detected Using a 2.5 dB Threshold (see Crane, 1976)

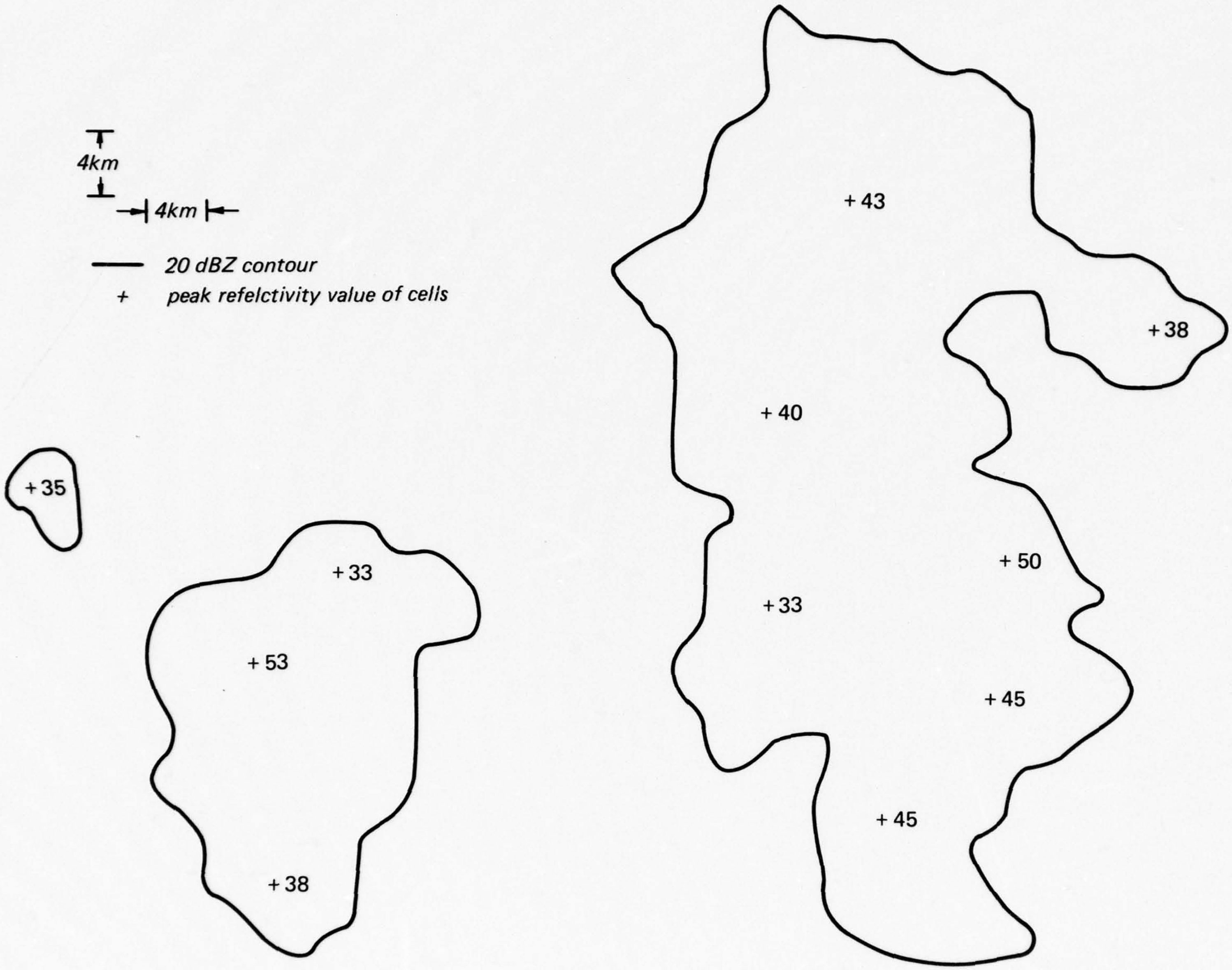

Figure 3 Simplified Display of the Essential Data Contained in Figure 2

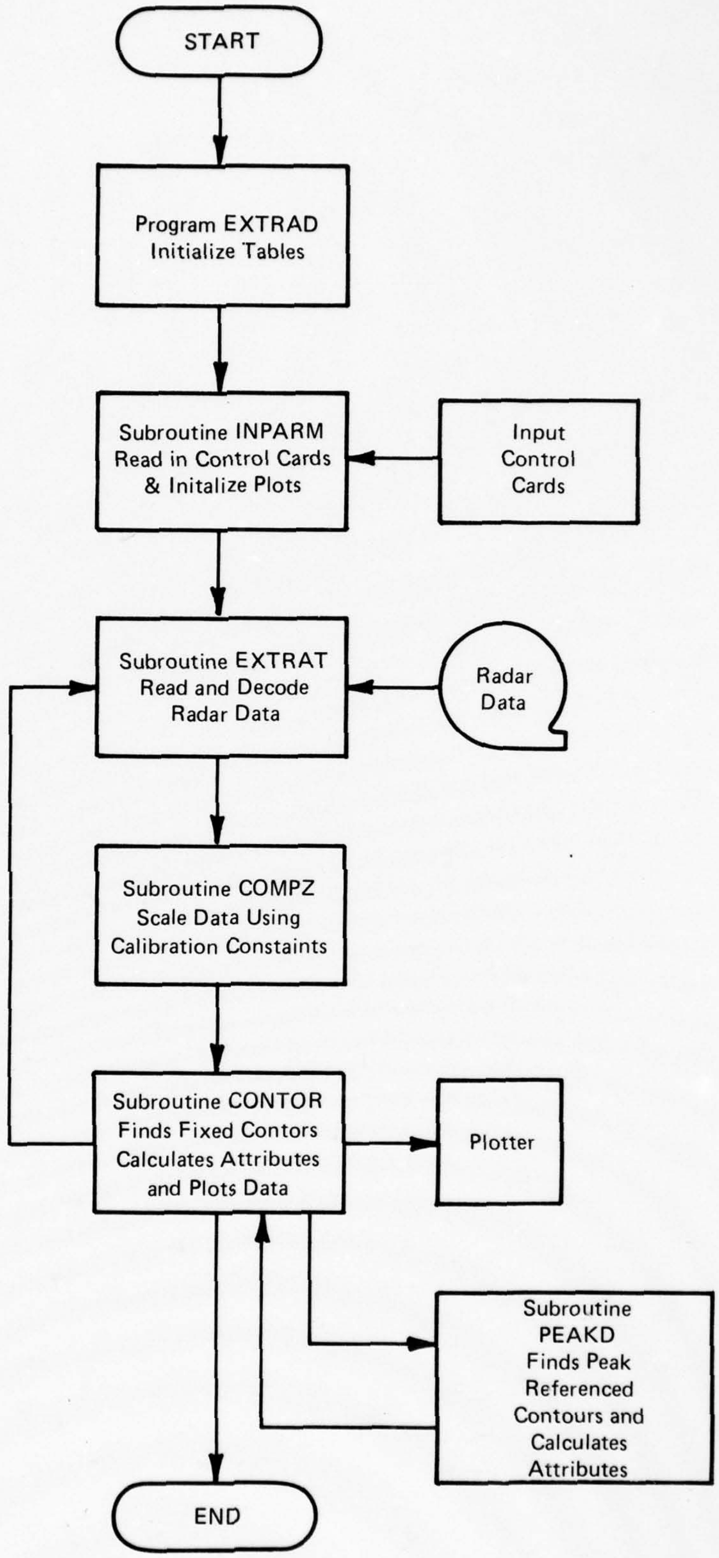

Figure 4 Computer Program Structure

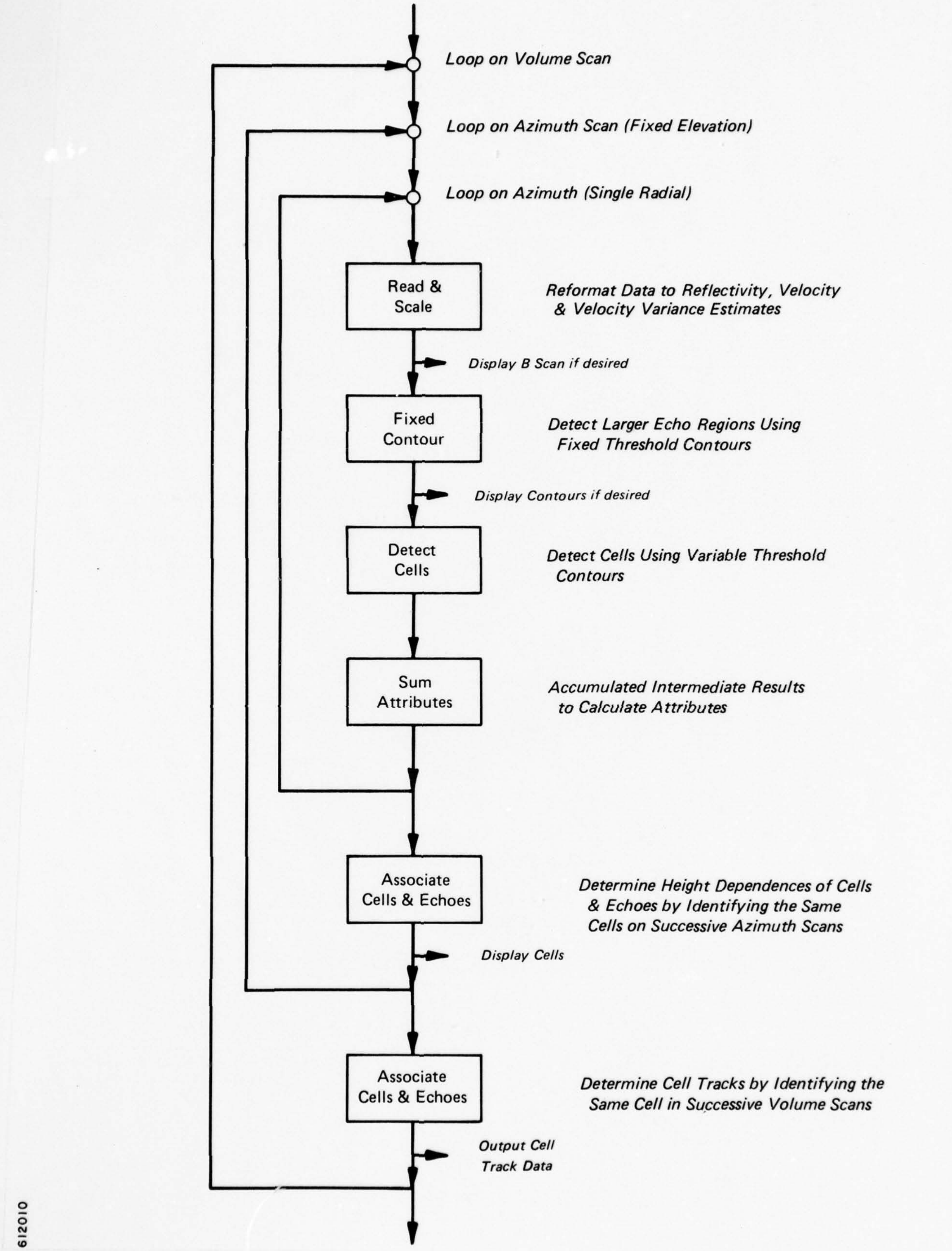

Figure 5 Overall Processing Scheme

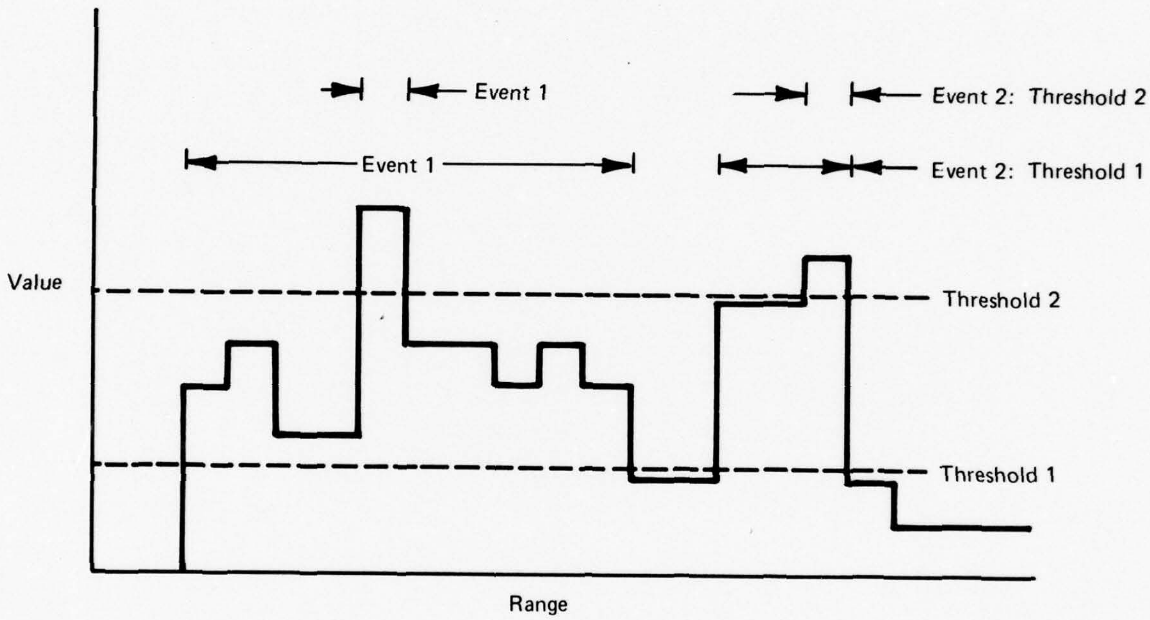

Figure 6 Event Definition

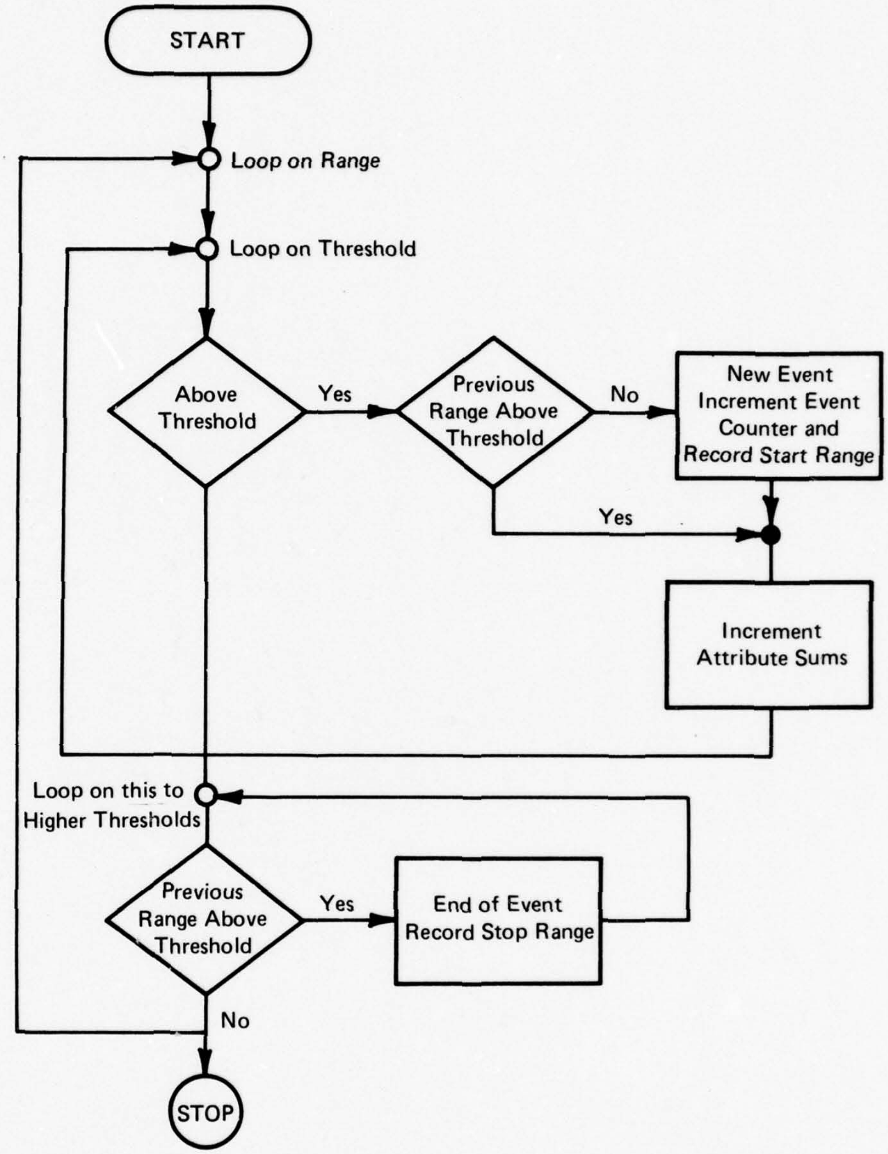

Figure 7 Event Identification

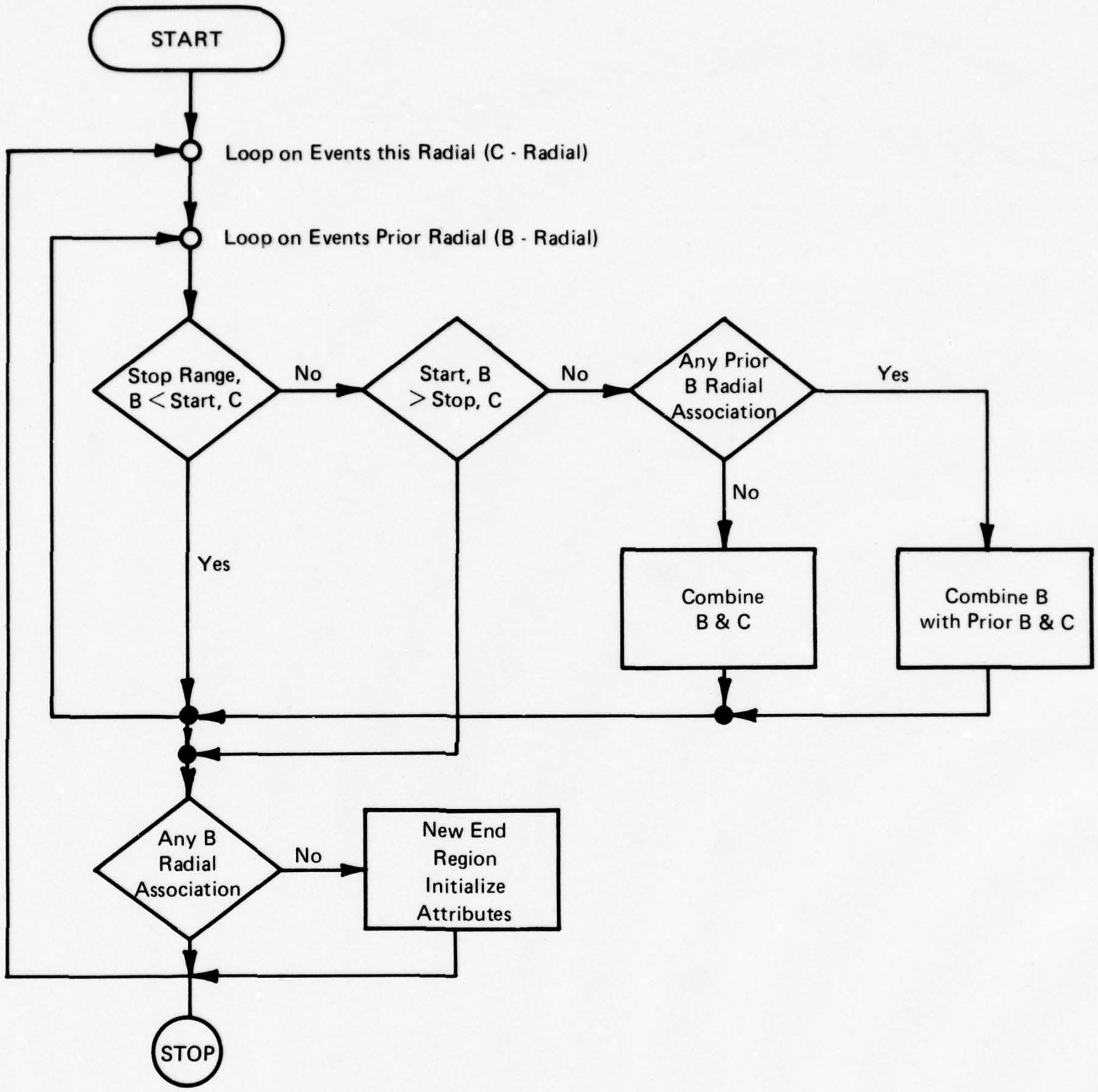

Figure 8 Event Association

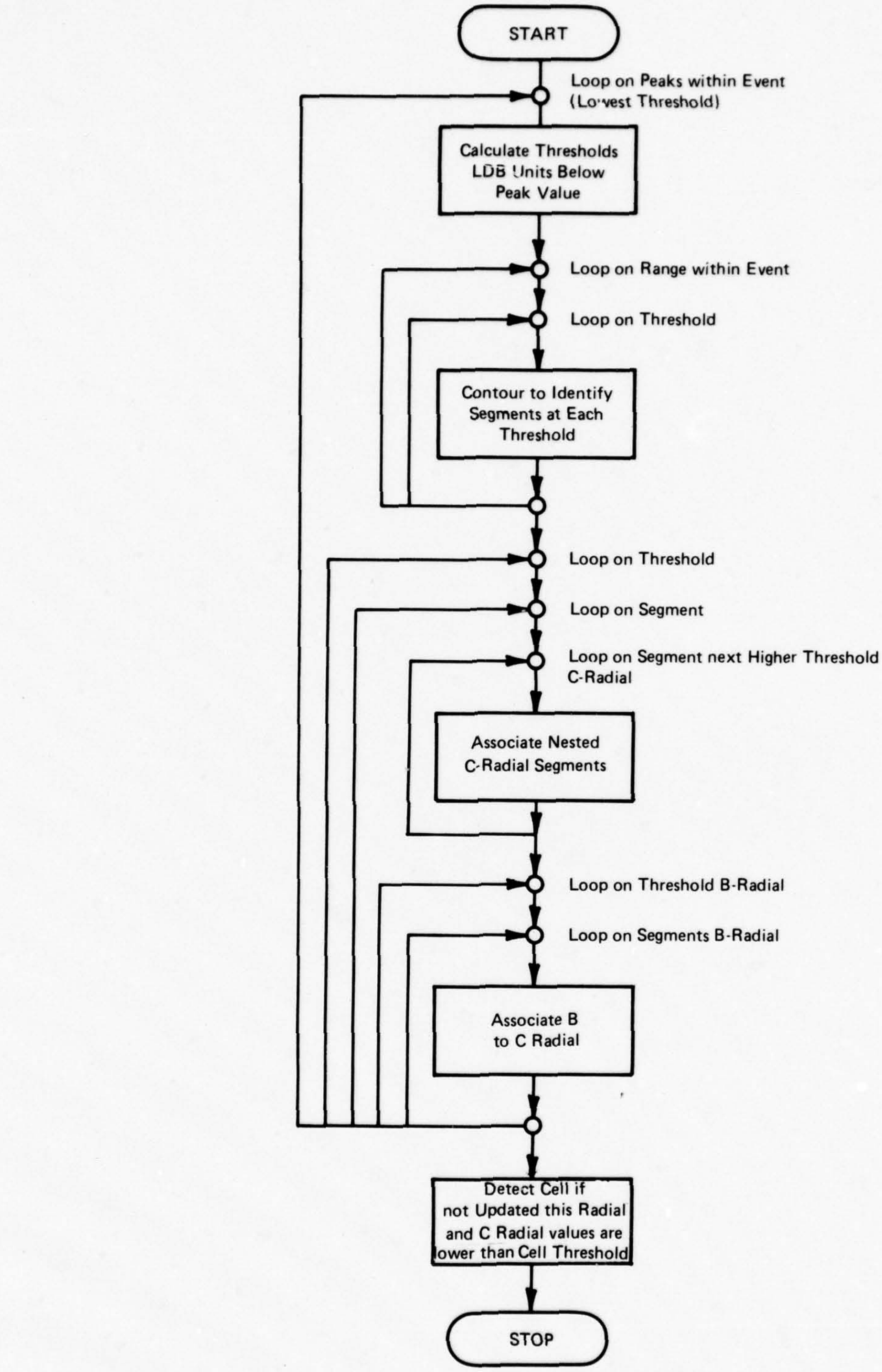

Figure 9 Peak Detection

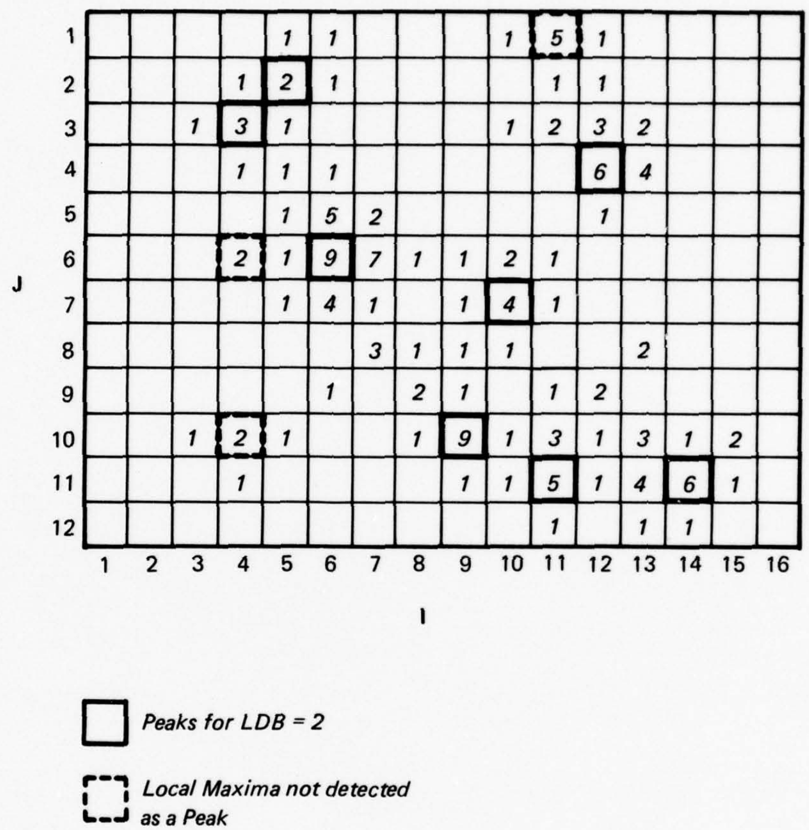

Figure 10 Example of Detected Peaks (see Tables 2 and 3)

```
                                            RANGE SCALE (   KM  )
    AZ       EL DAY HHMM SS           20.0    40.0    59.9    79.9    99.9   119.9   139.9   159.9

  206.0     1.0 225 1927 58
  207.1     1.0 226 1927 58
  207.9     1.0 226 1927 58
  209.0     1.0 226 1927 58
  209.8     1.0 225 1927 58
  210.7     1.0 226 1927 58
  211.6     1.0 226 1927 59
  212.9     1.0 226 1927 58
  213.8     1.0 226 1927 58
  214.8     1.0 226 1927 58
  215.6     1.0 225 1927 58                                    K
  216.6     1.0 226 1927 58                                K KKJ
  217.6     1.0 226 1928  0                             LLKKKJ
  218.5     1.0 226 1928  0                             LLKKKJJ
  219.6     1.0 226 1928  0                             LLK  JJ
  220.5     1.0 226 1928  0                              L  KKJ
  221.4     1.0 226 1928  0                                 N
  222.4     1.0 226 1928  0
  223.5     1.0 226 1928  0
  224.3     1.0 226 1928  0
  225.2     1.0 226 1928  0
  226.1     1.0 226 1928  0
  227.0     1.0 226 1928  1
  228.0     1.0 226 1928  0
  229.0     1.0 226 1928  2
  230.0     1.0 226 1928  2
  231.0     1.0 226 1928  2
  231.9     1.0 226 1928  2                 R    R
  232.8     1.0 226 1928  2                RR    R
  233.9     1.0 226 1928  2                PR   P
  234.8     1.0 226 1928  2                 R
  235.7     1.0 226 1928  2                RR
  236.5     1.0 226 1928  2                RR
  237.7     1.0 226 1928  2                RR
  238.5     1.0 226 1928  2                 R
  239.5     1.0 226 1928  2                                                R
  240.5     1.0 226 1928  2                RR
  241.3     1.0 226 1928  4                R
  242.4     1.0 226 1928  4                RR R  R                                              FFN
  243.5     1.0 226 1928  4                R     R                                             RRRR
  244.4     1.0 226 1928  4                      R                                      PJN
  245.3     1.0 226 1928  4                                                            KKPOPMOM
  246.3     1.0 226 1928  4                                                          LMLKOOCPPP
  247.1     1.0 226 1928  4                                                       PLKLKKLPPSP
  248.1     1.0 226 1928  4                                                 JPY JIONLNNNMPOWNNPP
  249.1     1.0 226 1928  4                      R                          LOXZJHARRRPPSKUMT
  250.0     1.0 226 1928  4                      R                         LLLVYJP     RRVLRP67
  250.9     1.1 226 1928  4                     RR                      LKLLLLV1R       31QM48
  251.9     1.0 226 1928  4                   R  P                     LKLLLLMV2          KK
  252.9     1.0 226 1928  6                   R  RR                    LKKMLKPY    NMNMLMNN
```

Figure 11a   B SCAN for Radial Velocity (see Figure 12 for calibration)

MAP OF POWER

RANGE SCALE (KM)

AZ	EL	DAY	HHMM	SS	20.0 40.0 59.9 79.9 99.9 119.9 139.9 159.9
207.1	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
207.9	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
209.0	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
209.8	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
210.7	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
211.6	1.0	226	1927	59	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
212.9	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
213.8	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
214.8	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
215.6	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
216.6	1.0	226	1927	58	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAJATJBAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
217.6	1.0	226	1928	0	AAAAAAAAAAAAAACGLKLKAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
218.6	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAABJTJLJHAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
219.6	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAABIAAAGDAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
220.5	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAABDAABEAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
221.4	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAAAADAAEAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
222.4	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
223.5	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
224.3	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
225.2	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
226.1	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
227.0	1.0	226	1928	1	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
228.0	1.0	226	1928	0	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
229.0	1.0	226	1928	2	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
230.0	1.0	226	1928	2	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
231.0	1.0	226	1928	2	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
231.9	1.0	226	1928	2	AAAAAAAABAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
232.8	1.0	226	1928	2	AAAAAAAACIAAAABAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
233.8	1.0	226	1928	2	AAAAAAAACIAAABAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
234.8	1.0	226	1928	2	AAAAAAAAAGAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
235.7	1.0	226	1928	2	AAAAAAAACHAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
236.6	1.0	226	1928	2	AAAAAAAADFAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
237.7	1.0	226	1928	2	AAAAAAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
238.5	1.0	226	1928	2	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
239.5	1.0	226	1928	2	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
240.5	1.0	226	1928	2	AAAAAAAADBAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
241.3	1.0	226	1928	4	AAAAAAAADAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
242.4	1.0	226	1928	4	AAAAAAAACAAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEGG
243.5	1.0	226	1928	4	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHJTE
244.4	1.0	226	1928	4	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEBBAAAAA
245.3	1.0	226	1928	4	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEJMNHBHEAA
246.3	1.0	226	1928	4	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHLNONOPLKHAA
247.1	1.0	226	1928	4	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAABAAADJLLNPPRPSOAAA
248.1	1.0	226	1928	4	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEMJAJOGLMMNOFTTPDDBAA
249.1	1.0	226	1928	4	AAAAAAAAAAAAAAFAAAAAAAAAAAAAAAAAAAAAAAAAAAANSPPTNAGIJDNOMPPOCAAA
250.0	1.0	226	1928	4	AAAAAAAAAAAAAATAAAAAAAAAAAAAAAAAAAAAAAAAAAAAJRSTTPBAAAACAKLLLLDAA
250.9	1.1	226	1928	4	AAAAAAAAAAAAACHAAAAAAAAAAAAAAAAAAAAAAHLLMORTQDAAAAAAAAADPLOOFAAA
251.9	1.0	226	1928	4	AAAAAAAAAAACABJAAAAAAAAAAAAAAAAAAAAAFLKLNLPIEAAAAAAAAAAAAAHJAAAA
252.9	1.0	226	1928	6	AAAAAAAAAAACAAJAAAAAAAAAAAAAAAAAAAAAAAAAEKHLLDGBAAAAACDBMKMLBAAA

EOF READ ON UNIT 1
EOF READ ON UNIT 1
EOF READ ON UNIT 1

Figure 11b B SCAN for Reflectivity (see Figure 12 for calibration)

CODE FOR MEAN	VALUE	CODE FOR VAR AND PWR	VALUE
A	-20.465		.993
B	-19.302	B	3.251
C	-18.140	C	5.508
D	-16.977	D	7.765
E	-15.814	E	10.023
F	-14.651	F	12.280
G	-13.488	G	14.537
H	-12.326	H	16.795
I	-11.163	I	19.052
J	-10.000	J	21.309
K	-8.837	K	23.567
L	-7.674	L	25.824
M	-6.512	M	28.081
N	-5.349	N	30.339
O	-4.186	O	32.596
P	-3.023	P	34.853
Q	-1.860	Q	37.111
R	-.698	R	39.368
S	.465	S	41.625
T	1.628	T	43.883
U	2.791	U	46.140
V	3.953	V	48.397
W	5.116	W	50.655
X	6.279	X	52.912
Y	7.442	Y	55.169
Z	8.605	Z	57.427
1	9.767	1	59.684
2	10.930	2	61.941
3	12.093	3	64.199
4	13.256	4	66.456
5	14.419	5	68.713
6	15.581	6	70.971
7	16.744	7	73.228
8	17.907	8	75.485
9	19.070	9	77.743
.	20.233	.	80.000

Figure 12 B SCAN Codes for Radial Velocity and Reflectivity

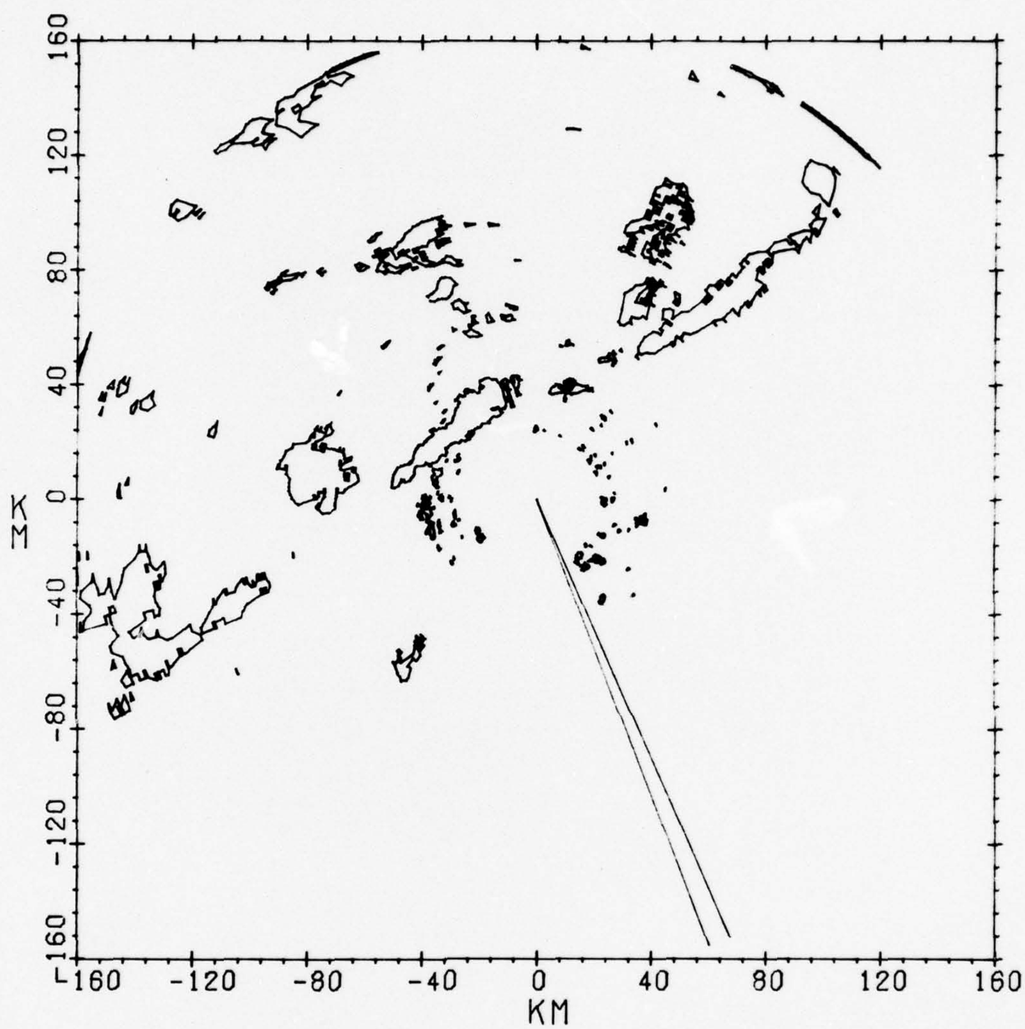

Figure 13 Plot of 20 dBZ Contour Generated Using the Computer Program - The Lines Denote Scan Boundaries

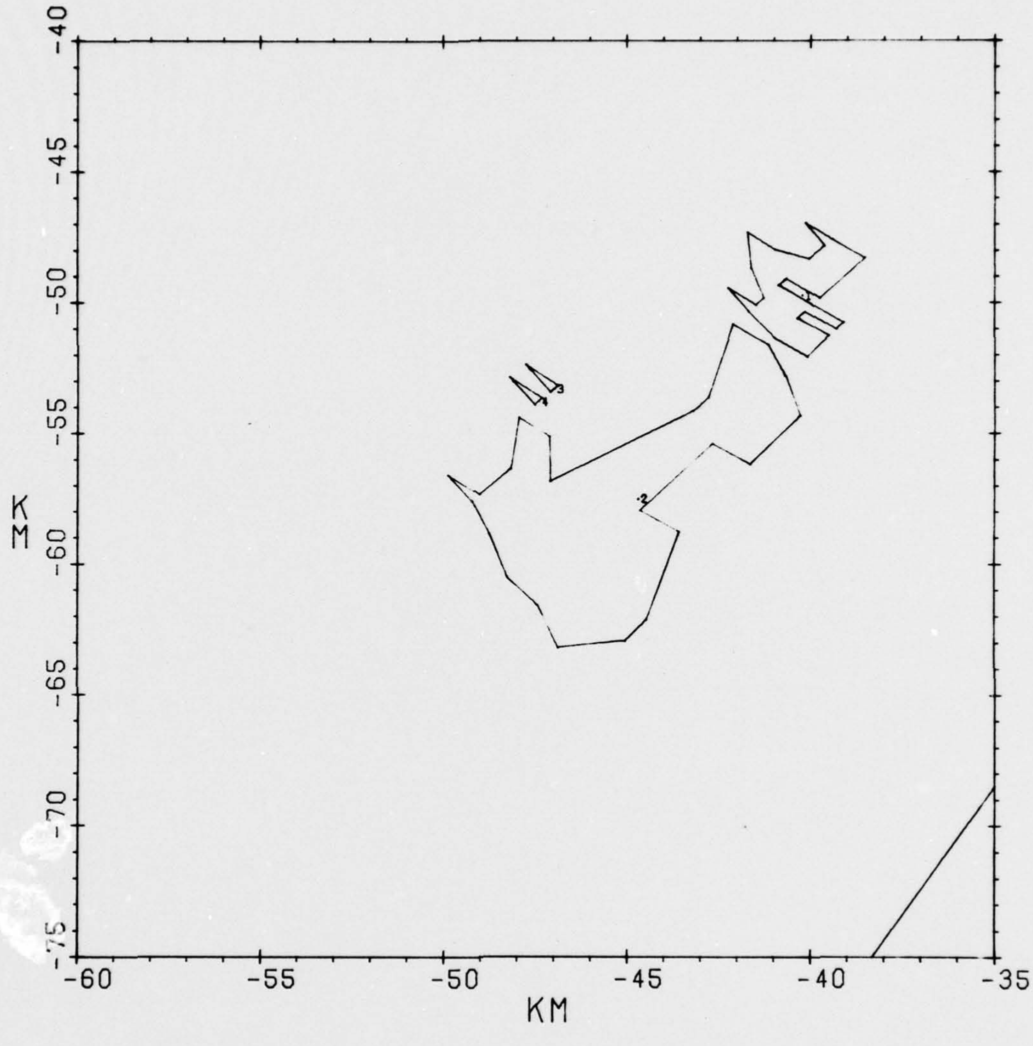

Figure 14 An Expanded Section of the Contour Map Presented in Figure 13 - The Centroid of Each Contour is Marked and Labeled

FIXED CONTOUR ATTRIBUTES

ID	THRESHOLD (DBZ)	AREA (KM**2)	AVERAGE REFLECTIVITY (DBZ)	LOCATION EAST (KM)	LOCATION NORTH (KM)	TOTAL PRECIP (TONS/HR)	AVERAGE PRECIP (MM/HR)
1	20	8.68	21.9	-38.7	-47.[illegible]	4.38	.50
2	20	40.85	24.5	-42.9	-55.[illegible]	30.86	.76
3	20	.33	21.0	-45.1	-51.[illegible]	.14	.44
4	20	.33	21.0	-43.5	-51.[illegible]	.14	.44

Figure 15 Fixed Contour Attributes for Contours Displayed on Figure 14

PEAK DETECTED CELL ATTRIBUTES

ID	REFLECTIVITY (DBZ)	AREA (KM**2)	LOCATION EAST (KM)	LOCATION NORTH (KM)	AVERAGE RADIAL SHEAR (M/S/KM)	AVERAGE TANGENTIAL SHEAR (M/S/KM)	MEAN RADIAL VELOCITY (M/S)
1	27.2	5.3	-43.6	-56.8	-.00	0.00	-8.73
2	27.3	3.[illegible]	-42.1	-53.7	.02	0.00	-8.48
3	24.0	1.3	-38.8	-48.1	0.00	0.00	-8.00

Figure 16 Small Cell Attributes for Contours Displayed on Figure 14

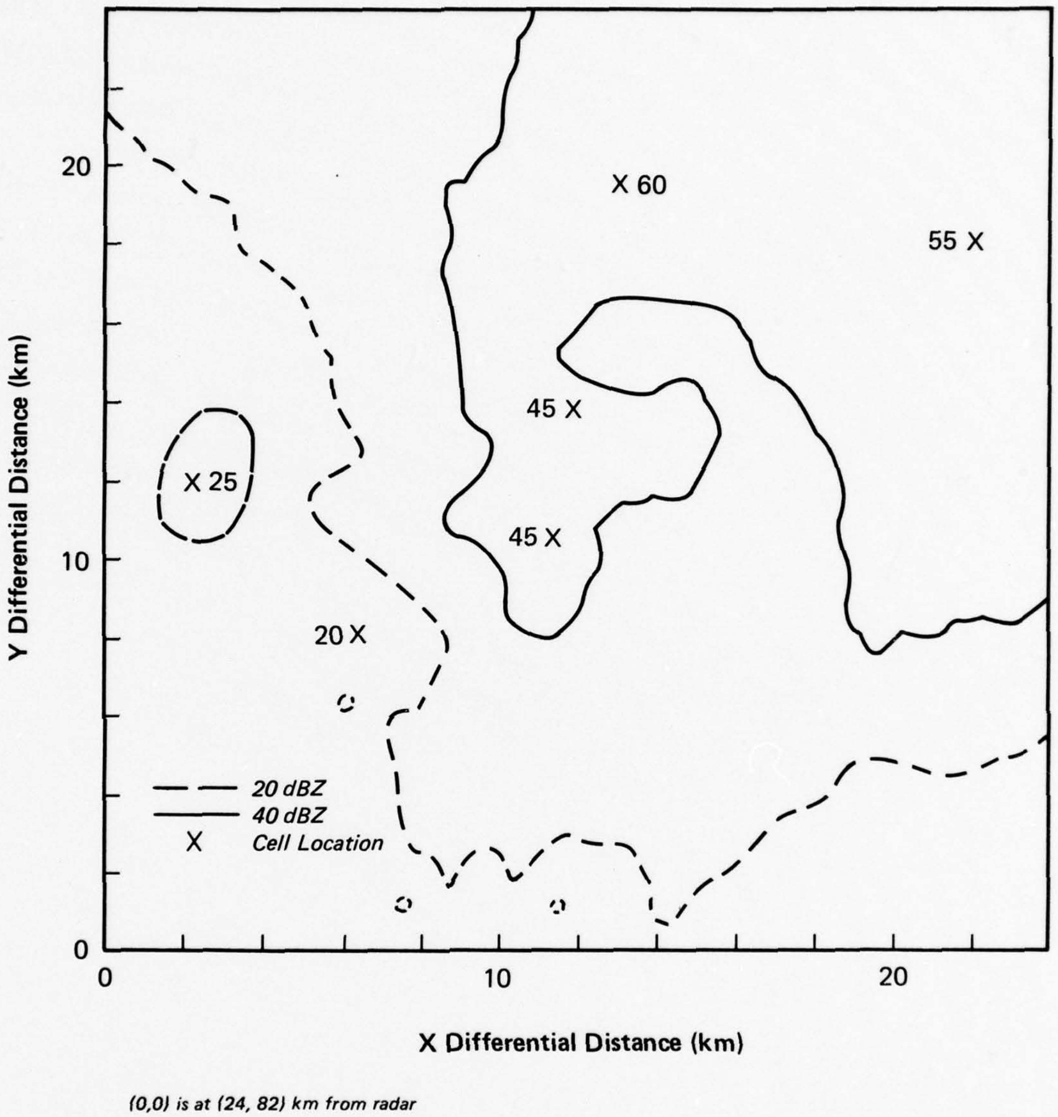

Figure 17 Reflectivity Structure for the Stillwater Tornado at 1.5 km Height

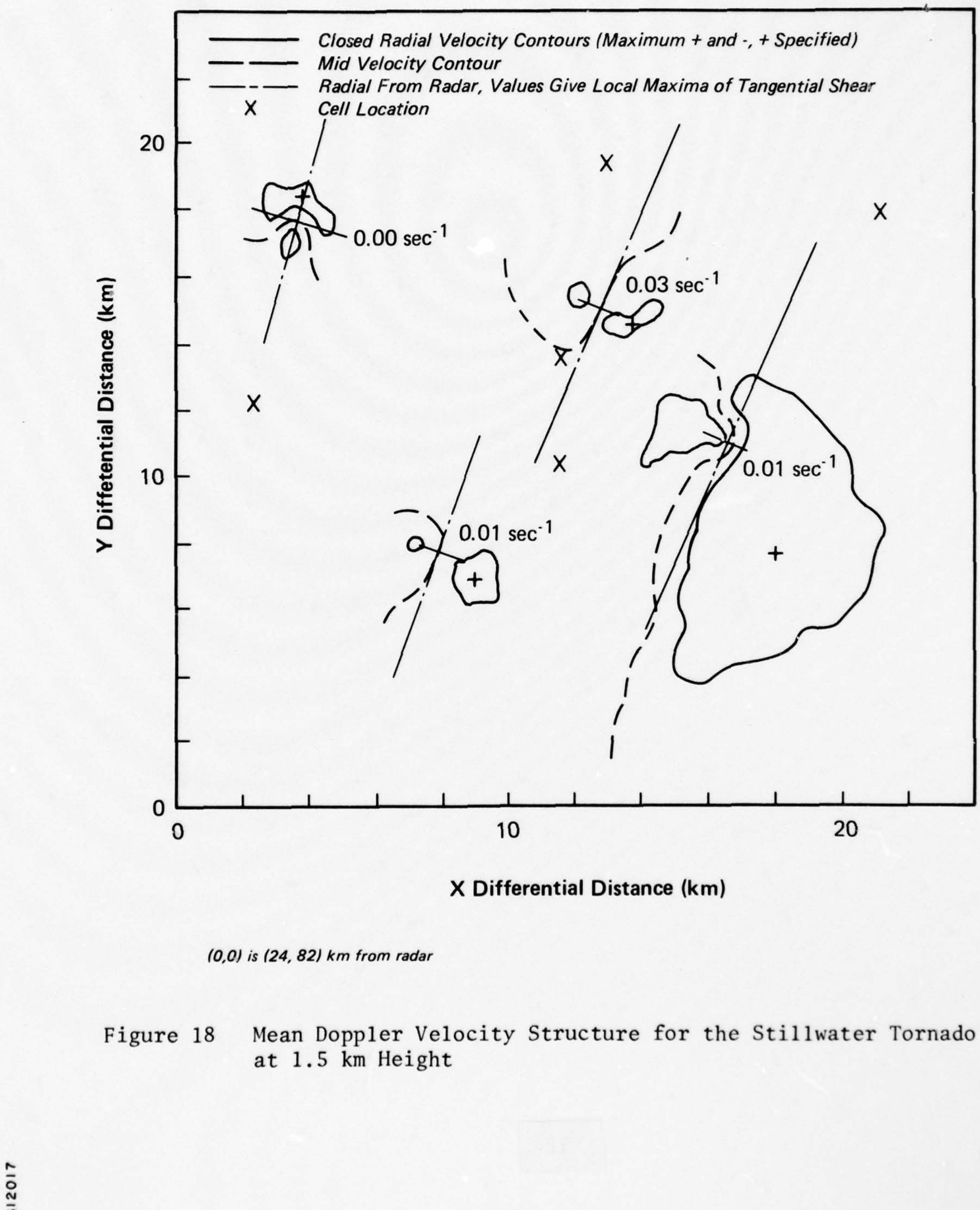

Figure 18 Mean Doppler Velocity Structure for the Stillwater Tornado at 1.5 km Height

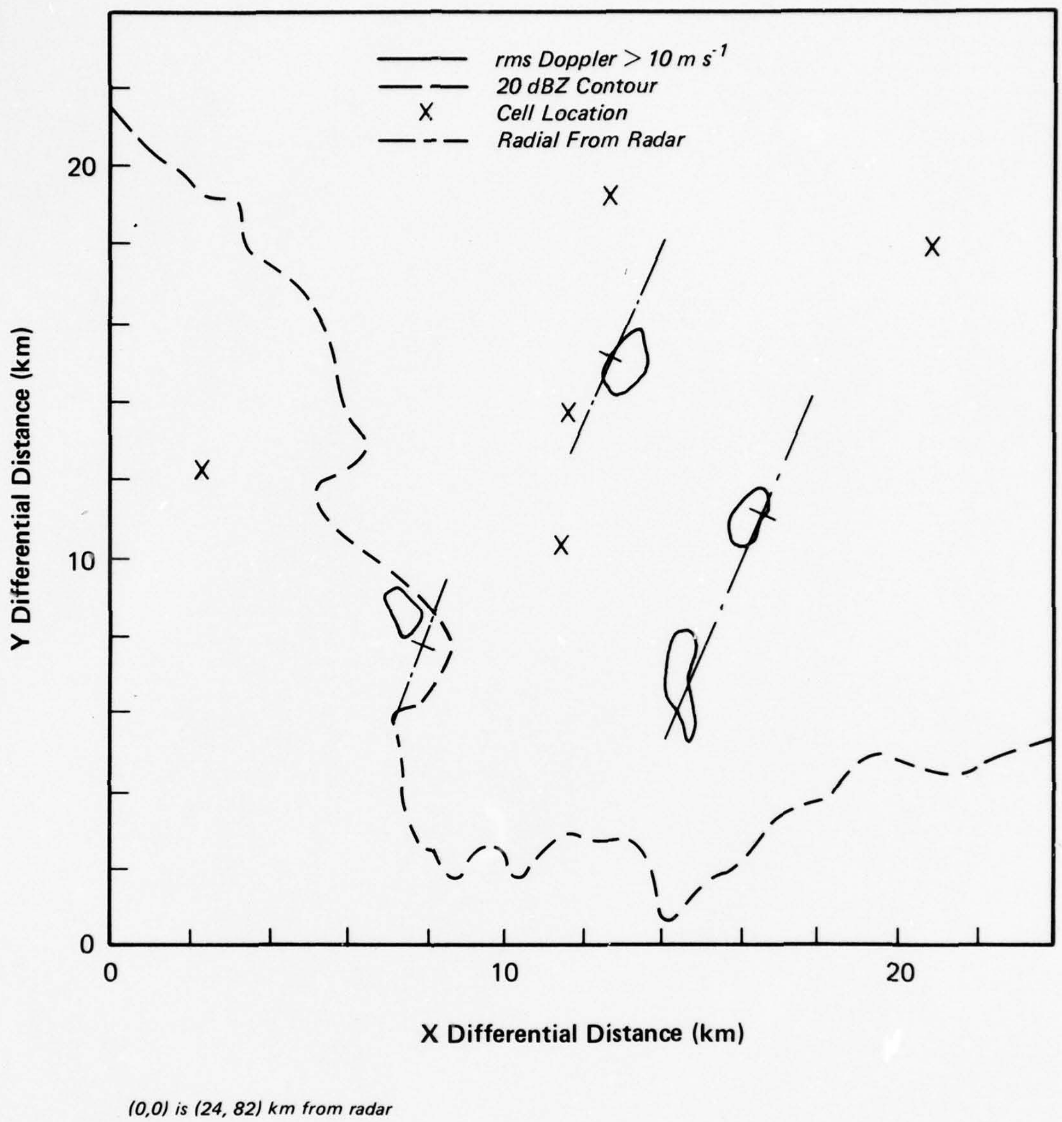

Figure 19 RMS Doppler Velocity Fluctuation Structure for the Stillwater Tornado at 1.5 km Height

612018

APPENDIX A

PROGRAM OPERATION

A.1 Description of Input and Output

Program input and output are depicted in Figure A1. The tape input format is given in Table A1. The control cards are discussed in section A2. The program produces (a) tapes of computed attributes for input to a second program for computing volume scans; (b) a plot tape is generated that can be stored for input to another program "EXPAND" which is a general purpose plotting package for plotting the fixed contours, centroids, cell identification and peak locations expanded over selected areas; (c) B-scan maps are also produced as an option; (d) full scan fixed contour plots of the lowest threshold level can be obtained on 35 mm film as the program is executing; (e) hard copy plots can also be obtained; and (f) at the completion of a scan the program will print out fixed contour attributes, peak detected cell attributes and tangential shear maxima attributes. All of the attributes printed have identifiers which can be associated with the identifiers displayed on the expanded plots.

A.2 Control Card Format

Control card input to the program is NAMELIST input which allows certain parameters in the program to default or to be set to different values. The variable names, type (LOGICAL L, INTEGER I, and REAL R), dimension, default value and their meanings are listed in Table A2.

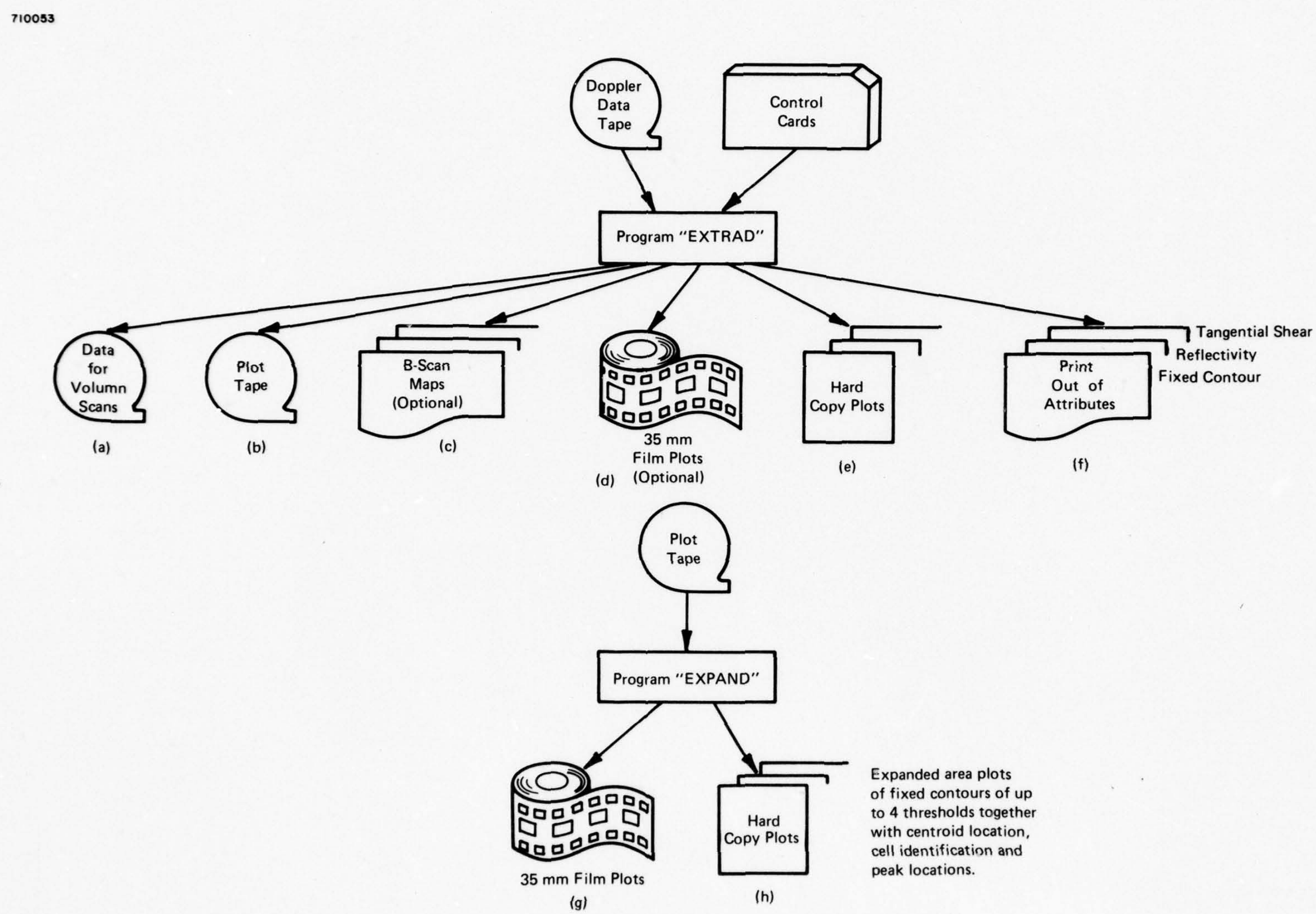

Figure A1 EXTRAD Products

		2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	12 Bit Word Position
ANCILLARY DATA	Day	800	400	200	100	80	40	20	10	8	4	2	1	1
	Hour				20	10	8	4	2	1				2
	Min			40	20	10	8	4	2	1				3
	Sec						40	20	10	8	4	2	1	4
	Status		T_p1	T_p0	SF_1	SF_0		DD	1) NRC_1	1) NRC_0				5
				B					A					
	*PRF	PRF_{11}	PRF_{10}	PRF_9	PRF_8	PRF_7	PRF_6	PRF_5	PRF_4	PRF_3	PRF_2	PRF_1	PRF_0	6
	Azimuth	AZ_{11}	AZ_{10}	AZ_9	AZ_8	AZ_7	AZ_6	AZ_5	AZ_4	AZ_3	AZ_2	AZ_1	2) AZ_0	7
	Spare													8
	Spare													9
	Elevation	EL_{11}	EL_{10}	EL_9	EL_8	EL_7	EL_6	EL_5	EL_4	EL_3	EL_2	EL_1	2) EL_0	10
	Spare													11
	Spare													12
VIDEO DATA Repeated 256 times**	Mean	6) M_{11}	5) M_{10}	M_9	M_8	M_7	M_6	M_5	M_4	M_3	M_2	4) M_1	2) M_2	13 + (I-1)·3
	Variance	6) V_8	V_7	V_6	V_5	V_4	V_3	V_2	V_1	2) V_0				14 + (I-1)·3
	Power	6) P_8	P_7	P_6	P_5	P_4	P_3	P_2	P_1	2) P_0				15 + (I-1)·3

1)

Number Range Cells	NRC_1	NRC_0
256	0	0
512	0	1
768	1	0
1024	1	1

Frequency of Dump Pulses DD	
ALT	0
ALL	1

Subframe SF_1	SF_0
0	0
0	1
1	0
1	1

Cell Width	T_{p1}	T_{p0}
0.5 μs	0	0
1 μs	0	1
2 μs	1	0

2) Least Significant Bit
3) ---------
4) Not Included in Parity
5) Sign
6) Parity

1 physical record = 158 sixty bit words

* If any group A bit = 1 and any group B bit = 1: PRF = 394
If A has 1 bit and B has 3 bits: PRF = 794
If A has 3 or more and B has 1 or less: PRF = 1613
If A has 3 or more and B has 3 or more: PRF = 3333
If A has 2 bits or B has 2 bits: PRF = Previous PRF
If all zero for A and B groups: use an input PRF

** First cell is the 21st twelve bit data word.

TABLE A1

TABLE A2

CARD FORMAT FOR PROGRAM EXTRAD

Reads in program parameters via NAMELIST format.

NAMELIST VARIABLES: (Level 760916)

NAME	TYPE	DIMENSION	DEFAULT	MEANING
PRINT 1	L	1	FALSE	When.True.Program print outs unpacked raw digital data from the Doppler data tape.
PRINT 2	L	1	FALSE	Currently unused.
PRINT 3	L	1	FALSE	When.True.B-Scan maps are produced.
PRINT 4	L	1	FALSE	When.True.Full scan plots are generated.
ICODES	I	36	A thru Z then 1 thru 9 followed by a dot.	Codes for representing DBZ categories for B-Scan map output.
A1	R	1	.13779	In the linear equation y = mx+b For computing coded DBZ for B-scans, A1 = M and B1 = b.
AZ	R	1	.017	Not currently used.
BZ	R	1	18.6	Not currently used.
CONTRZ	L	1	FALSE	When.True.Fixed contours are generated and their attributes. .False.will ignore fixed contouring.
CONTRV	L	1	FALSE	When.True.Peak detection and their attributes will be generated..False.will ignor peak detection.
NFILE	I	1	1	Not currently used.
NUMF	I	1	1	Not currently used.
AC	R	4	-107.7,+1.97, -.094,+.0018	Calibration coefficients for computing DBM below a threshold XCUT. (See XCUT.)

NAME	TYPE	DIMENSION	DEFAULT	MEANING
CALM	R	1	.332	In the calibration equation y = mx+b, CALM = M and CALB = b.
XCUT	R	1	10.0	Threshold value that determines which equation to use for calibration. (linear or non-linear)
CK	R	1	10.0	In the equation for computing DBZ, hence K+P+ZOALOGIO(S(I-.5)) ·CL+.5 (1) K = CK.
ZMAX	R	1	0.0	Not currently used.
VMAX	R	1	0.0	Not currently used.
NREC	I	1	1	Not currently used.
NUMR	I	1	999	Number of radials to be processed. Use default value when doing full scan.
IRUN	I	1	0	Run number chosen by user.
INC	I	1	0	Not currently used.
TL	I	4	20,30,40,50	DBZ fixed contouring thresholds.
LT	I	1	4	Number of fixed contour thresholds to produce. ($0<LT\leq 4$)
TDW	R	1	0.0	Not currently used.
DN	R	1	0.0	Not currently used.
STARTR	I	1	1	Not currently used.
DELTR	R	1	1.0	Not currently used.
INPRF	I	1	3333	Value of PRF (Pulse Repetition Frequency). To be used when PRF cannot be obtained from the data tape.
SCALE	R	1	1.0	Scale factor for drawing fixed contours.
AE	R	1	1.21	Constant for computing heights of cells.
AA	R	1	300	Constant for computing heights of cells.

NAME	TYPE	DIMENSION	DEFAULT	MEANING
BB	R	1	1.5	Constant for computing heights of cells.
X1	R	1	0.0	Frame size coordinates for fixed contour plotting. Less than or equal to 8 inches.
X2	R	1	8.0	Same as above.
Y1	R	1	0.0	Same as above.
Y2	R	1	8.0	Same as above.
TV	I	1	35	Velocity attributes are not computed for DBZ greater than this value.
TSV	R	1	10^6	Not currently used.
LDV	I	1	3	Cell detection treshold for reflectance peaks.
LTV	I	1	2	Cell detection threshold for velocity peaks.

APPENDIX B

COMPUTER PROGRAM LISTING

Preceding Page Blank - Not Filmed

```
      PROGRAM EXTRAD(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE1=0,
     *               TAPE2,OPT=0,DEBUG=OUTPUT)
C     PROGRAM EXTRAD   ERT NO. 162
C     VERSION 2.0   LEVEL 761119
C     MAIN PROGRAM SECTION.
C     JHW      AFGL      CDC 6600
C     *****************************************************************
      LOGICAL PRINT1,PRINT2,PRINT3,PRINT4,CONTRZ,CONTRV
      INTEGER CWRD(3)
      COMMON /PARM/ PRINT1,PRINT2,PRINT3,PRINT4,ICODES(36),A1,B1,A2,B2,C
     1ONTRZ,CONTRV,NFILE,NUMF,NREC,NUMR
      DATA CWRD/4HPARA,4HEXEC,4HCOMM/
C     -----------------------------------------------------------------
      CALL DAY
1     READ (5,11) KEY
11    FORMAT (A4)
      IF (EOF(5)) 91,21,91
21    CALL PAGE
      WRITE (6,31) KEY
31    FORMAT (1H ,A4)
      DO 41 K=1,3
      IF (KEY.EQ.CWRD(K)) GO TO (61,71,81), K
41    CONTINUE
      WRITE (6,51)
51    FORMAT (16H ILLEGAL KEYWORD)
      GO TO 91
C
C                 * PARAMETERS * PACKAGE.
C
61    CALL INPARM
      GO TO 1
C
C                 * EXECUTION * PACKAGE.
C
71    CALL EXTRAT
      GO TO 1
C
C                 * COMMENTS CARD * PACKAGE.
C
81    CALL INE (5)
      GO TO 1
C
C                 END OF JOB.
C
91    WRITE (6,101)
101   FORMAT (//2X,7H ENDJOB)
      IF (.NOT.PRINT4) GO TO 111
      CALL ENDPLT
111   STOP
      END
```

61

```
      BLOCK DATA
C     ******************************************************************
C     FOR PROGRAM EXTRAD   ERT NO. 162
C     VERSION 2.0   LEVEL 761119
C     JHW  CDC6600  AFGL
C     ******************************************************************
      LOGICAL PRINT1,PRINT2,PRINT3,PRINT4,CONTRZ,CONTRV
      INTEGER TL,STARTR,TV,TSV
C     ------------------------------------------------------------------
      COMMON /PARM/ PRINT1,PRINT2,PRINT3,PRINT4,ICODES(36),A1,B1,A2,B2,C
     1ONTRZ,CONTRV,NFILE,NUMF,NREC,NUMR
      COMMON /INSUB/ TL(4),LT,TDW,DN,STARTR,DELTR,RN(4),SCON,CELWTH(3)
      COMMON /AZM/ AZMUTH(460),NA,ELEVAT,PRF,KEEP
      COMMON /A1024/ MVP(3,1024)
      COMMON /VALMAX/ ZMAX,VMAX,AC(4),CALM,CALB,XCUT,CK,INC
      COMMON /ADATA/ IDAY,IHOUR,IMIN,ISEC,NTP,NSF,NDD,NRC
      COMMON /HEAD/ TITLE(6),ICODE,VERS,LEVEL,DAT,IRUN,NPAGE,NLOG
      COMMON /LINUM/ LINE
C     ******************************************************************
      COMMON /MORED/ INPRF,SCALE,LDV,LTV
      COMMON /STORE/ AE,AA,BB,SL,CL,TV,TSV
      COMMON /EXPAN/ X1,X2,Y1,Y2,XMIN,XMAX,YMIN,YMAX
C     ------------------------------------------------------------------
      DATA PRINT1/.FALSE./,PRINT2/.FALSE./,PRINT3/.FALSE./,PRINT4/.FALSE
     1./,A1/.13779/,B1/1.5/,A2/.017/,B2/18.6/,CONTRZ/.FALSE./,CONTRV/.FA
     2LSE./,NFILE/1/,NUMF/1/,NREC/1/,NUMR/999/
      DATA TL/20,30,40,50/
      DATA X1/0.0/,X2/8.0/,Y1/0.0/,Y2/8.0/,AE/1.21/,AA/300./,BB/1.5/
      DATA SL/0.0/,CL/0.0/,TV/35/,TSV/1000000/
      DATA LT/4/,STARTR/1/,DELTR/1.0/
      DATA TDW/0.0/,DN/0.0/,RN/256.0,512.0,768.0,1024.0/,SCON/299.7925/
      DATA CELWTH/0.5,1.042,2.0/
      DATA ICODES/1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,1HM,1H
     1N,1HO,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ,1H1,1H2,1H3,1H4,
     21H5,1H6,1H7,1H8,1H9,1H./
      DATA ZMAX/0.0/,VMAX/0.0/,AC/-107.76555,1.9767838,-.094297528,.0001
     18226318/,CALM/0.332/,CALB/-98.3/,XCUT/10.0/
      DATA TITLE/7HPROGRAM,7H EXTRAD,1H ,1H ,1H ,1H /
      DATA IRUN/0/,NPAGE/0/,ICODE/162/,VERS/1.0/,LEVEL/760916/
      DATA INPRF/3333/
      DATA CK/10.0/
      DATA SCALE/1.0/,LDV/3/,LTV/2/
C     ------------------------------------------------------------------
      END
```

```
      SUBROUTINE INPARM
C     ******************************************************************
C     VERSION 2.0   LEVEL 761119
C     JHW    AFGL    CDC6600
C     CONTROL CARD INPUT PARAMETERS.
C     ******************************************************************
      LOGICAL PRINT1,PRINT2,PRINT3,PRINT4,CONTRZ,CONTRV
      INTEGER TL,STARTR,TV,TSV
C     ------------------------------------------------------------------
      DIMENSION PROGID(3)
      COMMON /PARM/ PRINT1,PRINT2,PRINT3,PRINT4,ICODES(36),A1,B1,A2,B2,C
     1ONTRZ,CONTRV,NFILE,NUMF,NREC,NUMR
      COMMON /VALMAX/ ZMAX,VMAX,AC(4),CALM,CALB,XCUT,CK,INC
      COMMON /HEAD/ TITLE(6),ICODE,VERS,LEVEL,DAT,IRUN,NPAGE,NLOG
      COMMON /INSUB/ TL(4),LT,TDW,DN,STARTR,DELTR,RN(4),SCON,CELWTH(3)
      COMMON /MORED/ INPRF,SCALE,LDV,LTV
      COMMON /EXPAN/ X1,X2,Y1,Y2,XMIN,XMAX,YMIN,YMAX
      COMMON /STORE/ AE,AA,BB,SL,CL,TV,TSV
C     ------------------------------------------------------------------
      DATA PROGID/7HWILLAND,1H ,1H /
      NAMELIST /INPUT/ PRINT1,PRINT2,PRINT3,PRINT4,ICODES,A1,B1,A2,B2,CO
     1NTRZ,CONTRV,NFILE,NUMF,AC,CALM,CALB,XCUT,CK,ZMAX,VMAX,NREC,NUMR,IR
     2UN,INC,TL,LT,TDW,DN,STARTR,DELTR,INPRF,SCALE,AE,AA,BB,X1,X2,Y1,Y2,
     3TV,TSV,LDV,LTV
C     ------------------------------------------------------------------
      READ (5,INPUT)
      IF (EOF(5)) 111,1,111
1     WRITE (6,INPUT)
      IF (.NOT.CONTRZ) GO TO 21
      IF (.NOT.PRINT4) GO TO 11
      CALL CRTPLT (PROGID,1.0,17.0)
      CALL PLOT (0.0,0.0,3)
      CALL PLOT (8.,0.,2)
      CALL PLOT (8.,8.,2)
      CALL PLOT (0.,8.,2)
      CALL PLOT (0.,0.,2)
      X=SIN(0.0)+4.0
      Y=COS(0.0)+8.0
      CALL PLOT(X,Y,3)
      Y=Y-.25
      CALL PLOT(X,Y,2)
11    SCALE=8.0/(Y2-Y1)
      IF ((X2-X1).GT.(Y2-Y1)) SCALE=8.0/(X2-X1)
      XMIN=SCALE*X1
      XMAX=SCALE*X2
      YMIN=SCALE*Y1
      YMAX=SCALE*Y2
21    IF (.NOT.PRINT2) GO TO 61
C
C               PRINT ICODES VALUES.
C
      CALL PAGE
      WRITE (6,31)
31    FORMAT (1H0,8X,13HCODE FOR MEAN,7X,5HVALUE,5X,12HCODE FOR VAR,7X,5
     1HVALUE/40X,7HAND PWR)
```

```
      DO 41 I=1,36
      XA=(FLOAT(I)-B1)/A1
      IF (XA.LT.0.) XA=0.
      XB=(FLOAT(I)-B2)/A2
41    WRITE (6,51) ICODES(I),XB,ICODES(I),XA
51    FORMAT (15X,A1,9X,F9.3,11X,A1,9X,F9.3)
61    CONTINUE
      IF (.NOT.PRINT3) GO TO 101
      CALL PAGE
      WRITE (6,71)
71    FORMAT (1H0,8X,13HCODE FOR  DBZ,7X,5HVALUE)
      DO 81 I=1,36
      XA=(FLOAT(I)-B1)/A1
      IF (XA.LT.0.) XA=0.
81    WRITE (6,91) ICODES(I),XA
91    FORMAT (15X,A1,9X,F9.3)
101   CONTINUE
      RETURN
111   WRITE (6,121)
121   FORMAT (30H END OF FILE IN NAMELIST INPUT)
      STOP
      END
```

```
      SUBROUTINE EXTRAT
C     ******************************************************************
C     PJP   MODIFIED 4/27/77        MOD. 1.0
C     VERSION 1.0   LEVEL=760916
C     JHW   AFGL   CDC 6600
C     UNPACKING ROUTINE.
C     ******************************************************************
      LOGICAL PRINT1,PRINT2,PRINT3,PRINT4,CONTRZ,CONTRV
      INTEGER VJ(514),UI(514),VSI(514)
      INTEGER W(514),V(514),VS(514),SV(514),VB(514),HB(514),HVB(514),
     1 T(50),TC(10,30),TB(10,30),KDD(4),IPTB(30),IPLO(10,10),IPB1(10,
     210,30),IPB2(10,10,30),IPB3(10,10,30),IPC1(10,10,30),IPC2(10,10,30)
     3,IPC3(10,10,30),IC1(4,30,4),IPBNT(10,30),IPCNT(10,30),IB(4,30,4),I
     4C(4,30,4),IPTC(30),TC1(10,10,30),IPTC1(30),IPC1T(10,10,30),IPC2T(1
     50,10,30),IPC3T(10,10,30),ICVNT(4),IBVNT(4),IDC(30),IDVC(30),IPVRNG
     6(10,30),IPRNG(10,30),IPCNTT(10,30),IACT(100),IACV(100)
      INTEGER TL,STARTR
      REAL UP(8,100),DI(30),HZ(2,15,30),VI(3,15,30),CI(3,30,4),ATR(5,100
     1,4),ZH(12,15,100),DSI(100),TATR(33,100),CI1(3,30,4),UV(5,100),
     2VATR(17,100),BI(3,30,4)
C     ------------------------------------------------------------------
      DIMENSION IN(158)
      DIMENSION DAYMSK(3),IDAYSFT(3),HRMSK(2),IHRSFT(2),MINMSK(2),
     CIMINSFT(2),SECMSK(2),ISECSFT(2),MVPMSK(5),IMVPSFT(5)
      COMMON/WORK/W,V,VS,SV,VB,VJ,UI,VSI,HB,HVB,NCL
      COMMON /AZM/ AZMUTH(460),NA,ELEVAT,PRF,KEEP
      COMMON /PARM/ PRINT1,PRINT2,PRINT3,PRINT4,ICODES(36),A1,B1,A2,B2,C
     1ONTRZ,CONTRV,NFILE,NUMF,NREC,NUMR
      COMMON /A1024/ MVP(3,1024)
      COMMON /VALMAX/ ZMAX,VMAX,AC(4),CALM,CALB,XCUT,CK,INC
      COMMON /ADATA/ IDAY,IHOUR,IMIN,ISEC,NTP,NSF,NDD,NRC
      COMMON /MORED/ INPRF,SCALE,LDV,LTV
      COMMON /INSUB/ TL(4),LT,TDW,DN,STARTR,DELTR,RN(4),SCON,CELWTH(3)
      COMMON /AZ2/SINA,COSA,DELTAZ,ISCANF,NEL
C     ------------------------------------------------------------------
      DATA MVPMSK/77770000000000000000B,
     C00007777000000000000B,
     C00000000777700000000B,
     C00000000000077770000B,
     C00000000000000007777B/
      DATA DAYMSK/00170000000000000000B,
     C03600000000000000000B,
     C74000000000000000000B/
      DATA HRMSK/00000170000000000000B,
     C00000600000000000000B/
      DATA   MINMSK/00000000017000000000B,
     C00000000160000000000B/
      DATA SECMSK/00000000000000170000B,
     C00000000000000160000B/
      DATA IREGMSK/00007777000000000000B/
      DATA NSMSK/00000000000000000600B/
      DATA VPMSK/00000000000000003770B/
      DATA MEANM2/00000000000000001777B/
      DATA ISGNMSK/00000000000000002000B/
      DATA ELMSK/00000000000000007777B/
```

```
      DATA MEANM1/00000000777700000000B/
      DATA VARMSK1/00000000000077770000B/
      DATA PWRMSK1/00000000000000007777B/
      DATA AZMSK/00007777000000000000B/
      DATA NMSK/74000000000000000000B/
      DATA NRCMSK/00000000000000000030B/
      DATA NSFMSK/00000000000000000600B/
      DATA NDDMSK/00000000000000000040B/
      DATA NTPMSK/00000000000000003000B/
      DATA KMSK/00360000000000000000B/
      DATA IPARMSK/00000000000000004000B/
      DATA IMVPSFT/12,24,-24,-12,0/
      DATA IDAYSFT/12,8,4/
      DATA IHRSFT/21,17/
      DATA IMINSFT/-27,29/
      DATA ISECSFT/-12,-16/
      DATA JMAX/10/,KMAX/10/,IEMAX/30/,IAT/5/,NID/100/,NFC/4/,NZP/12/,NZ
     1H/15/,NUP/8/,NHZ/2/,NVI/3/,NPA/4/,NUMAX/33/,NTT/50/,NCL/514/
      DATA DAZT/2.0/,NPB/3/,NUV/5/,NVMAX/17/
C     ------------------------------------------------------------------
C     IEMAX = MAXIMUM NO. EVENTS/RADIAL ; NID = NO. OF ID'S/SCAN.
C     NPA = NO. PARAMETERS ; NFC=NO. FIXED CONTOURS ; NA = AZIMUTH NO.
C     LDB = NO. PEAK CONTOURS.
C              NDD=FREQ. OF DUMP PULSES     ALT=0,ALL=1
C              NTP=CELL WIDTH 0,1,2  MEANING .5,1.042,2.
C              NSF=SUBFRAME 0,1,2,3
C              NRC=NO. RANGE CELLS   0,1,2,3  MEANING 256,512,768,1024
C     ------------------------------------------------------------------
      IEOF=0
      ISCANF=0
      NFC=LT
      NA=1
      NEL=1
      BUFFER IN (1,1) (IN(1),IN(158))
      IF (UNIT(1)) 1,181,201
1     DO 11 I=1,514
      W(I)=0
      V(I)=-999
      VS(I)=-999
11    SV(I)=-999
C
C              UNPACK DAY HOUR MINUTE SECOND AND STATUS FLAGS.
C
21    IDAY=0
      DO 23 I=1,3
      IDAY=IDAY+10**(I-1)*SHIFT(IN(1) .AND. DAYMSK(I),IDAYSFT(I))
23    CONTINUE
      IHOUR=0
      DO 25 I=1,2
      IHOUR=IHOUR+10**(I-1)*SHIFT(IN(1) .AND. HRMSK(I),IHRSFT(I))
25    CONTINUE
      IMIN=0
      DO 27 I=1,2
      IMIN=IMIN+10**(I-1)    IFT(IN(1) .AND. MINMSK(I),IMINSFT(I))
27    CONTINUE
```

```
      ISEC=0
      DO 29 I=1,2
      ISEC=ISEC+10**(I-1)*SHIFT(IN(1) .AND. SECMSK(I),ISECSFT(I))
29    CONTINUE
      NTP=SHIFT(IN(1) .AND. NTPMSK,-9)
      NSF=SHIFT(IN(1) .AND. NSMSK,-7)
      NDD=SHIFT(IN(1) .AND. NDDMSK,-5)
      NRC=SHIFT(IN(1) .AND. NRCMSK,-3)
C
C             UNPACK PRF AZIMUTH, AND ELEVATION.
C
      N=SHIFT(IN(2) .AND. NMSK,4)
      K=SHIFT(IN(2) .AND. KMSK,11)
      IF (K.EQ.0.AND.N.EQ.0) GO TO 41
      JA=0
      JB=0
      DO 31 I=1,4
      IREG=2**(I-1)
      IF ((IREG.AND.N).NE.0) JA=JA+1
      IF ((IREG.AND.K).NE.0) JB=JB+1
31    CONTINUE
      IF (JA.EQ.1.AND.JB.EQ.1) PRF=394.
      IF (JA.EQ.1.AND.JB.EQ.3) PRF=794.
      IF (JA.GE.3.AND.JB.LE.1) PRF=1613.
      IF (JA.GE.3.AND.JB.GE.3) PRF=3333.
      GO TO 51
41    PRF=INPRF
51    CONTINUE
      IREG=SHIFT(IN(2) .AND. AZMSK,24)
      AZMUTH(NA)=IREG*360.0/4096.
      IREG=SHIFT(IN(2) .AND. ELMSK,0)
      ELEVAT=IREG*360.0/4096.
      IF (ELEVAT.GT.180.) ELEVAT=ELEVAT-360.
C
C             UNPACK THE DATA.
C             NSF IS SUBFRAME.
C
      K=NSF*256+1
      KEEP=K
C
C             UNPACK FIRST DATA WORD.
C
      MVP(1,K)=SHIFT(IN(3) .AND. MEANM1,-24)
      MVP(2,K)=SHIFT(IN(3) .AND. VARMSK1,-12)
      MVP(3,K)=SHIFT(IN(3) .AND. PWRMSK1,0)
      N=3
C
C             UNPACK REMAINING DATA.
C
61    DO 65 I=1,3
      N=N+1
      DO 63 J=1,5
      IF(I .EQ. 1 .AND. (J .EQ. 1 .OR. J .EQ. 4))K=K+1
      IF(I .EQ. 1 .AND. (J .EQ. 1 .OR. J .EQ. 4))M=1
      IF(I .EQ. 2 .AND. (J .EQ. 2 .OR. J .EQ. 5))K=K+1
```

```
      IF(I .EQ. 2 .AND. (J .EQ. 2 .OR. J .EQ. 5))M=1
      IF(I .EQ. 3 .AND. (J .EQ. 3))K=K+1
      IF(I .EQ. 3 .AND. (J .EQ. 3))M=1
      MVP(M,K)=SHIFT(IN(N) .AND. MVPMSK(J),IMVPSFT(J))
      M=M+1
63    CONTINUE
65    CONTINUE
      IF(N .LT. 155) GO TO 61
C
C               CLEAN OFF EXTRA BITS.
C
      DO 71 I=KEEP,K
      IPAR1=SHIFT(MVP(1,I) .AND. IPARMSK,-11)
      IREG=SHIFT(MVP(1,I) .AND. ISGNMSK,-10)
      MVP(1,I)=MVP(1,I) .AND. MEANM2
      IF (IREG.GT.0) MVP(1,I)=-MVP(1,I)
      IPAR2=SHIFT(MVP(2,I) .AND. IPARMSK,-11)
      MVP(2,I)=SHIFT(MVP(2,I) .AND. VPMSK,-3)
      IPAR3=SHIFT(MVP(3,I) .AND. IPARMSK,-11)
      MVP(3,I)=SHIFT(MVP(3,I) .AND. VPMSK,-3)
71    CONTINUE
      IF (.NOT.PRINT1) GO TO 81
      CALL PRN1
C
C               GET NEXT TAPE RECORD.
C
81    BUFFER IN (1,1) (IN(1),IN(158))
      IF (UNIT(1)) 91,111,201
91    NS=SHIFT(IN(1) .AND. NSMSK,-7)
      IREG=SHIFT(IN(2) .AND. AZMSK,24)
      AZ=IREG*360.0/4096.
      DAZ=AZ-AZMUTH(NA)
      IF (ABS(DAZ).GT.DAZT) GO TO 101
      DAZS=SIGN(1.,DAZ)
      IF(NA.EQ.1)DAZF=DAZS
      IF (DAZF.EQ.DAZS) GO TO 141
101   AZ=AZ+360.*DAZF
      DAZ=AZ-AZMUTH(NA)
      IF (ABS(DAZ).GT.DAZT) GO TO 121
      DAZS=SIGN(1.,DAZ)
      IF (DAZF.NE.DAZS) GO TO 121
      IF (ABS(AZ-360.*DAZF-AZMUTH(1)).GT.DAZT) GO TO 141
C               FINISHED SCAN
      ISCANF=1
      AZ=AZ-360.*DAZF
      GO TO 131
111   IEOF=1
121   ISCANF=-1
131   CALL CONTR2 (JMAX,KMAX,IEMAX,IAT,NID,NFC,NZP,NZH,NUP,NUMAX,NHZ,NVI
     1,NPA,IPVRNG,IPRNG,IDC,IDVC,IPB1,IPB2,IPB3,IPC1,IPC2,IPC3,IPTB,TB,I
     2PBNT,IPCNT,T,IPTC,UP,TC,IB,IC,HZ,VI,ICVNT,IBVNT,DI,TC1,IPTC1,IPC1T
     3,IPC2T,IPC3T,CI,ATR,ZH,DSI,IPLO,TATR,KDD,NTT,CI1,IC1,NPB,
     4IPCNTT,IACT,IACV,NUV,NVMAX,UV,VATR,NNE,BI)
      IF (IEOF.EQ.1) GO TO 181
      IF (NA.GT.NUMR) RETURN
```

```
141   IF(NS .GT. NSF .OR. NS .GT. NRC)GO TO 21
      IF (.NOT.CONTRZ) GO TO 161
      CALL COMPZ
      CALL CONTOR (JMAX,KMAX,IEMAX,IAT,NID,NFC,NZP,NZH,NUP,NUMAX,NHZ,NVI
     1,NPA,IPVRNG,IPRNG,IDC,IDVC,IPB1,IPB2,IPB3,IPC1,IPC2,IPC3,IPTB,TB,I
     2PBNT,IPCNT,T,IPTC,UP,TC,IB,IC,HZ,VI,ICVNT,IBVNT,DI,TC1,IPTC1,IPC1T
     3,IPC2T,IPC3T,CI,ATR,ZH,DSI,IPLD,TATR,KDD,NTT,CI1,IC1,NPB,
     4IPCNTT,IACT,IACV,NUV,NVMAX,UV,VATR,NNE,BI)
161   NA=NA+1
      IF (NA.GT.NUMR) GO TO 121
      GO TO 1
181   WRITE (6,191)
191   FORMAT (19H EOF READ ON UNIT 1)
      IF (.NOT.PRINT2) GO TO 221
C     CALL PRN2(2)
      GO TO 221
201   WRITE (6,211)
211   FORMAT (21H PARITY ERR ON UNIT 1)
221   RETURN
      END
```

```
      SUBROUTINE COMPZ
C     ************************************************************************
C     VERSION 2.0   LEVEL 761119
C     JHW   AFGL   CDC6600
C     COMPUTES DBZ.
C     ************************************************************************
      INTEGER W,V,VS,SV,VB,VJ,UI,VSI,HB,HVB
      INTEGER TL,STARTR
C     ------------------------------------------------------------------------
      COMMON/WORK/W(514),V(514),VS(514),SV(514),VB(514),VJ(514),UI(514),
     1VSI(514),HB(514),HVB(514),NCL
      COMMON /A1024/ MVP(3,1024)
      COMMON /AZM/ AZMUTH(460),NA,ELEVAT,PRF,KEEP
      COMMON /VALMAX/ ZMAX,VMAX,AC(4),CALM,CALB,XCUT,CK,INC
      COMMON /ADATA/ IDAY,IHOUR,IMIN,ISEC,NTP,NSF,NDD,NRC
      COMMON /INSUB/ TL(4),LT,TDW,DN,STARTR,DELTR,RN(4),SCON,CELWTH(3)
C     ------------------------------------------------------------------------
C
C              FETCH NUMBER OF RANGE CELLS (N).
C
      VCON=    (.106/4)*PRF/2047
      N=RN(NRC+1)+1
      M=2
      IF (NRC.LT.2) GO TO 11
C
C              COMPRESS DATA DOWN TO AN NCL CELL RADIAL.
C
      M=N-1
      DO 1 K=2,M,2
      J=K/2
      DO 1 I=1,3
      MVP(I,J)=(MVP(I,K-1)+MVP(I,K))/2.0
1     CONTINUE
      N=NCL-4
11    M=2
C
C              COMPUTE DBZ
C
      DO 41 J=M,N
      P=MVP(3,J+2)
      IF (P.LE.XCUT) GO TO 21
C
C              USE LINEAR CALIBRATION.
C
      P=P*CALM+CALB
      GO TO 31
C
C              USE NON LINEAR CALIBRATION.
C
21    P=AC(1)+AC(2)*P+AC(3)*P**2+AC(4)*P**3
31    W(J)=CK+P+20.*ALOG10(SCON*(FLOAT(J-1)-.5))*CELWTH(NTP+1)+.5
      IF (W(J).LT.TL(1)) W(J)=0
C
C              COMPUTE V
C
```

```
      IF (W(J).LE.TL(1)) GO TO 41
      V(J)=IFIX(VCON*FLOAT(MVP(1,J+2)))
      SV(J)=IFIX(VCON**2*FLOAT(MVP(2,J+2)))
      IF (VB(J).EQ.-999.OR.NA.EQ.1) GO TO 41
      R=SCON*(FLOAT(J-1)-.5)*CELWTH(NTP+1)
      VS(J)=(V(J)-VB(J))/R*1000.
41    CONTINUE
      DO 51 J=1,NCL
51    VB(J)=V(J)
      DO 61 J=1,NCL
61    VJ(J)=V(J)
      RETURN
      END
```

```
      SUBROUTINE PRANG
C     ***************************************************************************
C     VERSION 2.0   LEVEL 761119
C     JHW   CDC6600
C     COMPUTES RANGES AND PRINTS THEM OUT FOR BSCAN MAPS.
C     ***************************************************************************
      DIMENSION RSAVE(8)
      COMMON/INSUB/TL(04),LT,TDW,DN,STARTR,DELTR,RN(4),SCON,CELWTH(3)
      COMMON/ADATA/IDAY,IHOUR,IMIN,ISEC,NTP,NSF,NDD,NRC
C     ---------------------------------------------------------------------------
      SCRA=SCON
      IF(NRC.EQ.3)SCRA=SCON/2
      RMAX=SCRA*(RN(NRC+1)-.5)*CELWTH(NTP+1)/1000.
      D=RMAX/8.0
      RSAVE(8)=RMAX
      J=7
      DO 10 I=1,7
      RSAVE(J)=RSAVE(J+1)-D
      J=J-1
   10 CONTINUE
      CALL PAGE
      WRITE(6,99)RSAVE
   99 FORMAT(1H0,31X,20HRANGE SCALE (   KM   )/
     X4X,2HAZ,4X,2HEL,1X,3HDAY,1X,4HHHMM,1X,2HSS,6X,8F8.1,10H        PRF)
      RETURN
      END
```

```
      SUBROUTINE CONTOR (JMAX,KMAX,IEMAX,IAT,NID,NFC,NZP,NZH,NUP,NUMAX,N
     1HZ,NVI,NPA,IPVRNG,IPRNG,IDC,IDVC,IPB1,IPB2,IPB3,IPC1,IPC2,IPC3,IPT
     2B,TB,IPBNT,IPCNT,T,IPTC,UP,TC,IB,IC,HZ,VI,ICVNT,IBVNT,DI,TVB,IPTVB
     3,IPV1,IPV2,IPV3,CI,ATR,ZH,DSI,IPLO,TATR,KDD,NTT,CI1,IC1,NPB
     4      ,IPBVNT,IACT,IACV,NUV,NVMAX,UV,VATR,NNE,BI)
C     ******************************************************************
C     VERSION 2.0   LEVEL 761119
C     JHW   AFGL   CDC6600
C       FIXED CONTOURS, PEAK DETECTION, EVENT ASSOCIATION.
C     ******************************************************************
      LOGICAL PRINT1,PRINT2,PRINT3,PRINT4,CONTRZ,CONTRV
      INTEGER T(NTT),KDD(NFC),IPVRNG(JMAX,IEMAX),IPRNG(JMAX,IEMAX),IDC(I
     1EMAX),IDVC(IEMAX),IPC1(JMAX,KMAX,IEMAX),IPC2(JMAX,KMAX,IEMAX),IPC3
     2(JMAX,KMAX,IEMAX),IPTB(IEMAX),IPTC(IEMAX),IPBNT(KMAX,IEMAX),IPCNT(
     3KMAX,IEMAX),IB(NPA,IEMAX,NFC),IC(NPA,IEMAX,NFC),TC(KMAX,IEMAX),IPL
     4O(JMAX,KMAX),TB(KMAX,IEMAX),IBVNT(NFC),ICVNT(NFC),IC1(NPA,IEMAX,NF
     5C),IPB1(JMAX,KMAX,IEMAX),IPB2(JMAX,KMAX,IEMAX),IPB3(JMAX,KMAX,IEMA
     6X),IACT(NID),IACV(NID),IPV1(JMAX,KMAX,IEMAX),IPV2(JMAX,KMAX,IEMAX)
     7,IPV3(JMAX,KMAX,IEMAX),TVB(KMAX,IEMAX),IPBVNT(KMAX,IEMAX),IPTVB(IE
     8MAX)
      INTEGER W,V,VS,SV,VB,VJ,UI,VSI,HB,HVB
      INTEGER TL,STARTR,TV,TSV
      REAL UP(NUP,NID),HZ(NHZ,NZH,IEMAX),VI(NVI,NZH,IEMAX),DI(IEMAX),DSI
     1(NID),CI(NPB,IEMAX,NFC),ATR(IAT,NID,NFC),ZH(NZP,NNE,NID),TATR(NUMA
     2X,NID),CI1(NPB,IEMAX,NFC),VATR(NVMAX,NID),UV(NUV,NID),
     3 BI(NPB,IEMAX,NFC)
C     ------------------------------------------------------------------
      COMMON /STOR2/ IMX
      COMMON /INSUB/ TL(4),LT,TDW,DN,STARTR,DELTR,RN(4),SCON,CELWTH(3)
      COMMON /PARM/ PRINT1,PRINT2,PRINT3,PRINT4,ICODES(36),A1,B1,A2,B2,C
     1ONTRZ,CONTRV,NFILE,NUMF,NREC,NUMR
      COMMON /A1024/ MVP(3,1024)
      COMMON /AZM/ AZMUTH(460),NA,ELEVAT,PRF,KEEP
      COMMON /VALMAX/ ZMAX,VMAX,AC(4),CALM,CALB,XCUT,CK,INC
      COMMON /ADATA/ IDAY,IHOUR,IMIN,ISEC,NTP,NSF,NDD,NRC
      COMMON /MORED/ INPRF,SCALE,LDV,LTV
      COMMON /STORE/ AE,AA,BB,SL,CL,TV,TSV
      COMMON/WORK/W(514),V(514),VS(514),SV(514),VB(514),VJ(514),UI(514),
     1VSI(514),HB(514),HVB(514),NCL
      COMMON /AZ2/SINA,COSA,DELTAZ,ISCANF,NEL
C     ------------------------------------------------------------------
      DATA RPD/.017453/
      DATA IPUP/3000/,IPDN/2000/
C     ------------------------------------------------------------------
C               NTP=CELL WIDTH 0,1,2  MEANING .5,1.042,2.
C               NSF=SUBFRAME 0,1,2,3
C               NDD=FREQ. OF DUMP PULSES    ALT=0,ALL=1
C               NRC=NO. RANGE CELLS   0,1,2,3  MEANING 256,512,768,1024
C     ------------------------------------------------------------------
      IDSLOT=0
      IF (.NOT.PRINT3) GO TO 1
      IF (NA.EQ.1) CALL PRANG
      IF(.NOT.CONTRZ)RETURN
      IF(NA.EQ.1)WRITE(2) RN(NRC+1),CELWTH(NTP+1),ELEVAT
      CALL PRN3 (2,W)
```

```
1       CONTINUE
        IF (NA.EQ.1) GO TO 11
        TEMP=AZMUTH(NA-1)
        AZNOW=AZMUTH(NA)
        DELTAZ=(AZMUTH(NA)-TEMP)*RPD
        TEMP=TEMP*RPD
        GO TO 61
C
C                INITIALIZE.
C
11      TEMP=0.0
        DELTAZ=0.0
        AZNOW=0.0
        DO 21 K=1,NFC
21      KDD(K)=0
        SL=SIN(ELEVAT*RPD)/1000.
        CL=COS(ELEVAT*RPD)**2/AE/6.731E09
        NCEL=1
        NVCEL=1
        AR=ALOG10(AA)
        BR=0.1/BB
        AR=ALOG10(AA)
        BR=0.1/BB
        DO 31 K=1,NID
        DSI(K)=0.
        DO 31 J=1,NNE
        DO 31 L=1,NZP
31      ZH(L,J,K)=0.0
        DO 41 K=1,NID
        DO 41 J=1,IAT
        DO 41 L=1,NFC
41      ATR(J,K,L)=0.0
        DO 51 K=1,NFC
        DO 51 L=1,IEMAX
        DO 51 J=1,NPA
        IB(J,L,K)=0
51      IC(J,L,K)=0
61      CONTINUE
C
        DO 71 K=1,IEMAX
        DO 71 J=1,NZH
        DO 71 L=1,NHZ
71      HZ(L,J,K)=0.0
        DO 81 K=1,IEMAX
        DO 81 J=1,NVI
        DO 81 L=1,NZH
81      VI(J,L,K)=0.0
        DO 91 K=1,IEMAX
        DO 91 J=1,NFC
        DO 91 L=1,NPB
91      CI(L,K,J)=0.0
        DO 101 K=1,IEMAX
        DI(K)=0.0
        IDC(K)=0
        IDVC(K)=0
```

```
      DO 101 J=1,JMAX
      IPRNG(J,K)=0
      IPVRNG(J,K)=0
101   CONTINUE
      DO 111 K=1,NFC
      ICVNT(K)=0
111   CONTINUE
      IPV=0
      IP=0
      IPB=0
      IPVB=0
C
C               FIND EVENTS
C
      DO 281 I=2,NCL
      DO 231 K=1,NFC
      IF (W(I).GT.TL(K)) GO TO 131
      GO TO 241
131   IF (W(I-1).LE.TL(K)) GO TO 141
      GO TO 151
141   ICVNT(K)=ICVNT(K)+1
      IEVENT=ICVNT(K)
      IF (K.EQ.1) IEO=IEVENT
      IC(1,IEVENT,K)=I-1
      IC(3,IEVENT,K)=IEO
C
C               TALLY ATTRIBUTES.
C
151   R=SCON*(FLOAT(I-1)-.5)*CELWTH(NTP+1)
      IEVENT=ICVNT(K)
      CI(1,IEVENT,K)=CI(1,IEVENT,K)+R
      CI(2,IEVENT,K)=CI(2,IEVENT,K)+R*W(I)
      CI(3,IEVENT,K)=CI(3,IEVENT,K)+R*R*W(I)
      IF (K.NE.1) GO TO 231
C
C               PEAK DETECTION, LOCATE AND COUNT PEAKS.
C
      IF (W(I)-W(I-1)) 171,181,161
161   IPB=I-1
      GO TO 181
171   IF (IPB.EQ.0) GO TO 181
      IP=IP+1
      IPRNG(IP,IEVENT)=(I+IPB)/2
      IPB=0
181   CONTINUE
      IF (VS(I).EQ.-999) GO TO 191
      IF (VS(I-1).EQ.-999) GO TO 201
      IF (IABS(VS(I))-IABS(VS(I-1))) 191,211,201
191   IF (IPVB.EQ.0) GO TO 211
      IPV=IPV+1
      IPVRNG(IPV,IEVENT)=(I+IPVB)/2
      IPVB=0
      GO TO 211
201   IPVB=I-1
211   CONTINUE
```

```
      IH=IFIX(R*SL+R*R*CL)+1
      IF (IH.LE.0.OR.IH.GT.NZH) GO TO 221
      IE1=IEVENT
      HZ(1,IH,IE1)=HZ(1,IH,IE1)+W(I)*R
      HZ(2,IH,IE1)=HZ(2,IH,IE1)+R
      IF (W(I).GT.TV.OR.SV(I).GT.TSV) GO TO 221
      IF (W(I).LT.TL(1).OR.V(I).EQ.-999) GO TO 221
      VI(1,IH,IE1)=VI(1,IH,IE1)+V(I)
      VI(2,IH,IE1)=VI(2,IH,IE1)+V(I)*V(I)
      VI(3,IH,IE1)=VI(3,IH,IE1)+1.0
221   CONTINUE
      IF (NEL.NE.1) GO TO 231
      RAIN=10.**(BR*W(I)-AR)
      DI(IE1)=DI(IE1)+RAIN*R
231   CONTINUE
      GO TO 281
241   DO 271 KL=K,NFC
      IF (W(I-1).LE.TL(KL)) GO TO 281
      IEVENT=ICVNT(KL)
      IC(2,IEVENT,KL)=I-1
C
C              KEEP COUNT OF PEAKS WITH EVENT.
C
      IF (KL.NE.1) GO TO 271
      IF (IPB.EQ.0) GO TO 251
      IP=IP+1
      IPRNG(IP,IEVENT)=(I+IPB)/2
      IPB=0
251   IDC(IEVENT)=IP
      IP=0
      IF (IPVB.EQ.0) GO TO 261
      IPV=IPV+1
      IPVRNG(IPV,IEVENT)=(I+IPVB)/2
      IPVB=0
261   IDVC(IEVENT)=IPV
      IPV=0
271   CONTINUE
281   CONTINUE
      IF (NA.NE.1) GO TO 321
      DO 311 K=1,NFC
      DO 311 KEVENT=1,IEMAX
      DO 291 I=1,NPB
291   CI1(I,KEVENT,K)=CI(I,KEVENT,K)
      DO 301 I=1,NPA
301   IC1(I,KEVENT,K)=IC(I,KEVENT,K)
311   CONTINUE
321   COST=COS(TEMP)
      SINT=SIN(TEMP)
      COSA=COS(AZNOW*RPD)
      COSA2=COSA*COSA
      SINA=SIN(AZNOW*RPD)
      SINA2=SINA*SINA
      SNACNA=SINA*COSA
      IMX=RN(NRC+1)/2-3
      IF(NRC.EQ.1)IMX=NRC-3
```

76

```
C
C              PLOT FIXED CONTOURS.
C
      DO 611 K=1,NFC
      IPU=IPUP+K
      IPD=IPDN+K
      IDD=KDD(K)
      KEVENT=1
      IEVENT=1
331   IF (IB(2,IEVENT,K).EQ.0.AND.IC(2,KEVENT,K).EQ.0) GO TO 601
      IF (IB(1,IEVENT,K).GT.IC(2,KEVENT,K)) GO TO 471
      IF (IB(2,IEVENT,K).LT.IC(1,KEVENT,K)) GO TO 471
C
C              ASSOCIATED
C              LEFT SIDE PEN UP.
C
      IID=IB(NPA,IEVENT,K)
      IF (ISCANF.EQ.0) IC(NPA,KEVENT,K)=IID
      X=FLOAT(IB(1,IEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINT+4.0)
      Y=SCALE*(R*COST+4.0)
      IF (PRINT4) CALL PLOT (X,Y,3)
      WRITE(2)X,Y,IPU
C
C              LEFT SIDE PEN DOWN.
C
      X=FLOAT(IC(1,KEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINA+4.0)
      Y=SCALE*(R*COSA+4.0)
      IF (PRINT4) CALL PLOT (X,Y,2)
      WRITE(2)X,Y,IPD
341   ATR(1,IID,K)=ATR(1,IID,K)+DELTAZ*CI(1,KEVENT,K)
      ATR(2,IID,K)=ATR(2,IID,K)+DELTAZ*CI(2,KEVENT,K)
      ATR(3,IID,K)=ATR(3,IID,K)+SINA*DELTAZ*CI(3,KEVENT,K)
      ATR(4,IID,K)=ATR(4,IID,K)+COSA*DELTAZ*CI(3,KEVENT,K)
      IE1=IC(3,KEVENT,K)
      IID1=IC(NPA,IE1,1)
      IF (ATR(IAT,IID,K).EQ.0.) ATR(IAT,IID,K)=IID1
      IF (IC(1,KEVENT,K).EQ.1.OR.IC(2,KEVENT,K).EQ.IMX) ATR(IAT,IID,K)=-
     1ABS(ATR(IAT,IID,K))
      IF (K.NE.1) GO TO 371
      I2=NNE
      DO 361 IH=1,NZH
      IF (HZ(2,IH,KEVENT).LE.0) GO TO 361
      IF (VI(3,IH,KEVENT).LE.0) GO TO 351
      ZH(1,I2,IID)=ZH(1,I2,IID)+VI(1,IH,KEVENT)
      ZH(2,I2,IID)=ZH(2,I2,IID)+VI(2,IH,KEVENT)
      ZH(3,I2,IID)=ZH(3,I2,IID)+SINA*VI(1,IH,KEVENT)
      ZH(4,I2,IID)=ZH(4,I2,IID)+COSA*VI(1,IH,KEVENT)
      ZH(5,I2,IID)=ZH(5,I2,IID)+SINA2*VI(3,IH,KEVENT)
      ZH(6,I2,IID)=ZH(6,I2,IID)+COSA2*VI(3,IH,KEVENT)
      ZH(7,I2,IID)=ZH(7,I2,IID)+SNACNA*VI(3,IH,KEVENT)
      ZH(8,I2,IID)=ZH(8,I2,IID)+SINA*VI(3,IH,KEVENT)
```

```
      ZH(9,I2,IID)=ZH(9,I2,IID)+COSA*VI(3,IH,KEVENT)
      ZH(10,I2,IID)=ZH(10,I2,IID)+VI(3,IH,KEVENT)
351   ZH(11,I2,IID)=ZH(11,I2,IID)+HZ(1,IH,KEVENT)*DELTAZ
      ZH(12,I2,IID)=ZH(12,I2,IID)+HZ(2,IH,KEVENT)*DELTAZ
361   CONTINUE
      DSI(IID)=DSI(IID)+DI(KEVENT)*DELTAZ
371   IF (ISCANF.EQ.1.AND.IID.NE.IC(NPA,KEVENT,K)) GO TO 571
381   IF (IB(1,IEVENT+1,K).GT.IC(2,KEVENT,K)) GO TO 441
      IF (IB(1,IEVENT+1,K).EQ.0) GO TO 441
C
C              DRAW DOWN TO PRESENT AZMUTH.
C
      X=FLOAT(IB(2,IEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINT+4.0)
      Y=SCALE*(R*COST+4.0)
      IF (PRINT4) CALL PLOT (X,Y,3)
      WRITE(2)X,Y,IPU
      X=SCALE*(R*SINA+4.0)
      Y=SCALE*(R*COSA+4.0)
      IF (PRINT4) CALL PLOT (X,Y,2)
      WRITE(2)X,Y,IPD
      WRITE(2)X,Y,IPU
C
C              DRAW OVER TO IEVENT+1
C
      X=FLOAT(IB(1,IEVENT+1,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINA+4.0)
      Y=SCALE*(R*COSA+4.0)
      IF (PRINT4) CALL PLOT (X,Y,2)
      WRITE(2)X,Y,IPD
      WRITE(2)X,Y,IPU
C
C              DRAW UP TO PREVIOUS AZMUTH.
C
      X=SCALE*(R*SINT+4.0)
      Y=SCALE*(R*COST+4.0)
      IF (PRINT4) CALL PLOT (X,Y,2)
      WRITE(2)X,Y,IPD
      IEVENT=IEVENT+1
      IF (IEVENT.GT.IEMAX) GO TO 601
      KID=IB(NPA,IEVENT,K)
401   IF (ATR(IAT,KID,K).EQ.0.0.OR.ATR(IAT,IID,K).EQ.0.0) GO TO 381
      IATT=IAT-1
      DO 411 J=1,IATT
411   ATR(J,IID,K)=ATR(J,IID,K)+ATR(J,KID,K)
      IF (ATR(IAT,KID,K).LT.0.0.OR.ATR(IAT,IID,K).LT.0.0) ATR(IAT,IID,K)
     1=-ABS(ATR(IAT,IID,K))
C              A 0 WILL FLAG USELESS ATTR'S.
      ATR(IAT,KID,K)=0.0
      IDSLOT=KID
      I2=NNE
421   ZH(J,I2,IID)=ZH(J,I2,IID)+ZH(J,I2,KID)
      ZH(NZP,I2,KID)=0.0
```

```
      DSI(IID)=DSI(IID)+DSI(KID)
      GO TO 381
441   IF (IC(1,KEVENT+1,K).GT.IB(2,IEVENT,K)) GO TO 451
      IF (IC(1,KEVENT+1,K).EQ.0) GO TO 451
C
C              DRAW LINE CONNECTING IC(N) TO IC(N+1).
C
      X=FLOAT(IC(2,KEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINA+4.0)
      Y=SCALE*(R*COSA+4.0)
      IF (PRINT4) CALL PLOT (X,Y,3)
      WRITE(2)X,Y,IPU
      X=FLOAT(IC(1,KEVENT+1,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINA+4.0)
      Y=SCALE*(R*COSA+4.0)
      IF (PRINT4) CALL PLOT (X,Y,2)
      WRITE(2)X,Y,IPD
      KEVENT=KEVENT+1
      IC(NPA,KEVENT,K)=IID
      IF (KEVENT.LT.IEMAX) GO TO 341
      GO TO 601
C
C              RIGHT SIDE.
C
451   X=FLOAT(IB(2,IEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINT+4.0)
      Y=SCALE*(R*COST+4.0)
      IF (PRINT4) CALL PLOT (X,Y,3)
      WRITE(2)X,Y,IPU
      X=FLOAT(IC(2,KEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINA+4.0)
      Y=SCALE*(R*COSA+4.0)
      IF (PRINT4) CALL PLOT (X,Y,2)
      WRITE(2)X,Y,IPD
      IEVENT=IEVENT+1
      IF (IEVENT.GT.IEMAX) GO TO 601
      KEVENT=KEVENT+1
      GO TO 331
471   IF (IB(1,IEVENT,K).EQ.0) GO TO 521
      IF (IC(1,KEVENT,K).EQ.0) GO TO 481
C
C              UNASSOCIATED.
C              ANGLE LINE ON IB
C
      IF (IC(2,KEVENT,K).LT.IB(1,IEVENT,K)) GO TO 511
481   X=FLOAT(IB(1,IEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINT+4.0)
      Y=SCALE*(R*COST+4.0)
      IF (PRINT4) CALL PLOT (X,Y,3)
      WRITE(2)X,Y,IPU
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79

```
      X=SCALE*(R*SINA+4.0)
      Y=SCALE*(R*COSA+4.0)
      IF (PRINT4) CALL PLOT (X,Y,2)
      WRITE(2)X,Y,IPD
      WRITE(2)X,Y,IPU
      X=FLOAT(IB(2,IEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINT+4.0)
      Y=SCALE*(R*COST+4.0)
      IF (PRINT4) CALL PLOT (X,Y,2)
      WRITE(2)X,Y,IPD
      IID=IB(NPA,IEVENT,K)
      ATR(1,IID,K)=ATR(1,IID,K)+DELTAZ*BI(1,IEVENT,K)
      ATR(2,IID,K)=ATR(2,IID,K)+DELTAZ*BI(2,IEVENT,K)
      ATR(3,IID,K)=ATR(3,IID,K)+SINA*DELTAZ*BI(3,IEVENT,K)
      ATR(4,IID,K)=ATR(4,IID,K)+COSA*DELTAZ*BI(3,IEVENT,K)
      IE1=IC(3,KEVENT,K)
      IID1=IC(NPA,IE1,1)
      IF (ATR(IAT,IID,K).EQ.0.) ATR(IAT,IID,K)=IID1
      IF (IC(1,KEVENT,K).EQ.1.OR.IC(2,KEVENT,K).EQ.IMX) ATR(IAT,IID,K)=-
     1ABS(ATR(IAT,IID,K))
      IEVENT=IEVENT+1
      IF (IEVENT.GT.IEMAX) GO TO 601
      IF (IC(1,KEVENT,K).LE.IB(2,IEVENT,K)) GO TO 331
      IF (IC(2,KEVENT,K).NE.0) GO TO 501
      GO TO 331
501   IF (IB(1,IEVENT,K).EQ.0) GO TO 521
511   IF (IC(1,KEVENT,K).GT.IB(2,IEVENT,K)) GO TO 331
C
C               UNASSOCIATED
C               STRAIGHT LINE ON IC.
C
521   IF (IC(1,KEVENT,K).EQ.0) GO TO 562
      IF (ISCANF.EQ.1) GO TO 581
      IF(IDSLOT.EQ.0)GO TO 523
      IC(NPA,KEVENT,K)=IDSLOT
      GO TO 524
  523 IDD=IDD+1
      IC(NPA,KEVENT,K)=IDD
      IF (NA.EQ.1) IC1(NPA,KEVENT,K)=IDD
  524 X=FLOAT(IC(1,KEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINA+4.0)
      Y=SCALE*(R*COSA+4.0)
      IF (PRINT4) CALL PLOT (X,Y,3)
      WRITE(2)X,Y,IPU
      X=FLOAT(IC(2,KEVENT,K))-.5
      R=SCON*X*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SINA+4.0)
      Y=SCALE*(R*COSA+4.0)
      IF (PRINT4) CALL PLOT (X,Y,2)
      WRITE(2)X,Y,IPD
      IF (NA.EQ.1) GO TO 531
      IF(IDSLOT.EQ.0)GO TO 527
      IDTEMP=IDD
```

```
      IDD=IDSLOT
  527 ATR(1,IDD,K)=DELTAZ*CI(1,KEVENT,K)
      ATR(2,IDD,K)=DELTAZ*CI(2,KEVENT,K)
      ATR(3,IDD,K)=SINA*DELTAZ*CI(3,KEVENT,K)
      ATR(4,IDD,K)=COSA*DELTAZ*CI(3,KEVENT,K)
531   IE1=IC(3,KEVENT,K)
      ATR(IAT,IDD,K)=IC(NPA,IE1,1)
      IF (NA.EQ.1) ATR(IAT,IDD,K)=-ABS(ATR(IAT,IDD,K))
      IF (IC(1,KEVENT,K).EQ.1.OR.IC(2,KEVENT,K).EQ.IMX) ATR(IAT,IDD,K)=-
     1ABS(ATR(IAT,IDD,K))
      IF (K.NE.1) GO TO 561
      I2=NNE
      DO 551 IH=1,NZH
      IF (HZ(2,IH,KEVENT).LE.0.) GO TO 551
      IF (VI(3,IH,KEVENT).EQ.0.) GO TO 541
      ZH(1,I2,IDD)=VI(1,IH,KEVENT)
      ZH(2,I2,IDD)=VI(2,IH,KEVENT)
      ZH(3,I2,IDD)=SINA*VI(1,IH,KEVENT)
      ZH(4,I2,IDD)=COSA*VI(1,IH,KEVENT)
      ZH(5,I2,IDD)=SINA2*VI(3,IH,KEVENT)
      ZH(6,I2,IDD)=COSA2*VI(3,IH,KEVENT)
      ZH(7,I2,IDD)=SNACNA*VI(3,IH,KEVENT)
      ZH(8,I2,IDD)=SINA*VI(3,IH,KEVENT)
      ZH(9,I2,IDD)=COSA*VI(3,IH,KEVENT)
      ZH(10,I2,IDD)=VI(3,IH,KEVENT)
541   IF (NA.EQ.1) GO TO 561
      ZH(11,I2,IDD)=HZ(1,IH,KEVENT)*DELTAZ
      ZH(12,I2,IDD)=HZ(2,IH,KEVENT)*DELTAZ
551   CONTINUE
      DSI(IDD)=DI(KEVENT)*DELTAZ
  561 IF(IDSLOT.NE.0)IDD=IDTEMP
      IDSLOT=0
562   KEVENT=KEVENT+1
      IF (KEVENT.GT.IEMAX) GO TO 601
      GO TO 331
  571 KID=IC(NPA,KEVENT,K)
      IF (IC(1,KEVENT,K).EQ.1.OR.IC(2,KEVENT,K).EQ.IMX) GO TO 401
      ATR(IAT,KID,K)=ABS(ATR(IAT,KID,K))
      GO TO 401
581   IID=IC(NPA,KEVENT,K)
591   IF (IC(1,KEVENT,K).GT.1.AND.IC(2,KEVENT,K).LT.IMX) ATR(IAT,IID,K)=
     1ABS(ATR(IAT,IID,K))
      IF (ATR(IAT,IID,K).NE.0.) GO TO 341
      GO TO 591
601   KDD(K)=IDD
611   CONTINUE
782   IF(.NOT.CONTRV)GO TO 800
      CALL PEAKD (W,LDV,TL(1),IPRNG,IDC,1,TATR,IPB1,IPB2,IPB3,IPTB,TB,IP
     1BNT,IPCNT,T,IPC1,IPC2,IPC3,IPTC,UP,TC,NTT,IEMAX,KMAX,JMAX,      NCE
     2L,NID,IB,IC,ICVNT,IBVNT,NPA,NFC,IPLO,NUMAX,NUP,IACT,HB)
      CALL PEAKD(VS,LTV,0,IPVRNG,IDVC,0,VATR,IPV1,IPV2,IPV3,
     2IPTVB,TVB,IPBVNT,IPCNT,T,IPC1,IPC2,IPC3,IPTC,UV,TC,NTT,IEMAX,KMAX,
     3JMAX,NVCEL,NID,IB,IC,ICVNT,IBVNT,NPA,NFC,IPLO,NVMAX,NUV,IACV,HVB)
C
C               STORE PRESENT PARAMETERS IN PREVIOUS PARAMETERS.
```

```
      NAME=41
      WRITE(6,9909)NAME,INDX
365   CONTINUE
      GO TO 931
C
C                COMBINE NPCEL AND LPCEL, PEAK VALUES EQUAL
C
C
C                  COMBINE WITH B RADIAL CELLS
C
  421 IF(MPK.LT.0)GO TO 422
      LPCEL=MPK
      IF(TATR(IDX,LPCEL).EQ.NA.AND.NPK.EQ.0)GO TO 485
      INDX=TATR(1,LPCEL)-TC(KC,IE)-1
      IF(INDX.LT.0)GO TO 481
C
C                  COMBINE WITH B - RADIAL, C-LEVEL LOWER
C
      IPC3(IPE,KC,IE)=LPCEL
      IN=INDX*LM
512   IST=IPC1(IPE,KC,IE)+1
      ISP=IPC2(IPE,KC,IE)
      NPCEL=LPCEL
      DO 531 I=IST,ISP
      R=SCON*(FLOAT(I-1)-.5)*CELWTH(NTP+1)
      TATR(2+IN,NPCEL)=TATR(2+IN,NPCEL)+DAZ*R
      TATR(3+IN,NPCEL)=TATR(3+IN,NPCEL)+DAZ*R*U(I)
      TATR(4+IN,NPCEL)=TATR(4+IN,NPCEL)+DAZ*SAZ*R*R*U(I)
      TATR(5+IN,NPCEL)=TATR(5+IN,NPCEL)+DAZ*CAZ*R*R*U(I)
      IF (ITY.NE.1) GO TO 531
      IF (V(I).EQ.-999.OR.V(I-1).EQ.-999) GO TO 521
      TATR(6+IN,NPCEL)=TATR(6+IN,NPCEL)+DAZ*R*(V(I)-V(I-1))
521   IF (VS(I).EQ.-999) GO TO 531
      TATR(7+IN,NPCEL)=TATR(7+IN,NPCEL)+DAZ*R*VS(I)
      TATR(8+IN,NPCEL)=AMAX1(TATR(8+IN,NPCEL),FLOAT(IABS(VS(I))))
531   CONTINUE
      TATR(IDX+IN,NPCEL)=SIGN(FLOAT(NA),TATR(IDX+IN,NPCEL))
      IF(IST.EQ.2.OR.ISP.EQ.IMX)TATR(IDX+IN,NPCEL)=SIGN(TATR(IDX+IN,NPCE
     XL),-1.0)
      NAME=51
      WRITE(6,9909)NAME,IN
      WRITE(6,1071)NPCEL,(TATR(KZ,NPCEL),KZ=1,NUMP)
      GO TO 422
C
C                  COMBINE WITH B-RADIAL, C-LEVEL HIGHER
C
C                  IF FIRST COMBINE, AREA=0, IF SECOND OR HIGHER, AREA=-1.
C                  TEST AREA TO ESTABLISH NEW NUMBERS
C
  481 INDX=-INDX
      IND=NUMP
      INS=2
      TATR(1,LPCEL)=TC(KC,IE)+1
      TATR(NUMP,LPCEL)=IC(NPA,IE,1)
      IF(INDX.GE.LDB)GO TO 482
```

```
C
  800 DO 790 K=1,NFC
      DO 790 IEVENT=1,IEMAX
      DO 790 N=1,NPB
  790 BI(N,IEVENT,K)=CI(N,IEVENT,K)
      DO 801 K=1,NFC
      IBVNT(K)=ICVNT(K)
      DO 801 IEVENT=1,IEMAX
      DO 801 N=1,NPA
      IB(N,IEVENT,K)=IC(N,IEVENT,K)
801   IC(N,IEVENT,K)=0
      IF (ISCANF.EQ.1) GO TO 871
      RETURN
C
C
      ENTRY CONTR2
      IF (ISCANF.GT.0) GO TO 831
      DO 821 K=1,NFC
      IE=IBVNT(K)
      DO 821 I=1,IE
      IDD=IB(NPA,IE,K)
  821 ATR(IAT,IDD,K)=-ATR(IAT,IDD,K)
C               PLOT FINAL RADIALS.
      X=4.0
      Y=4.0
      IF(PRINT4)CALL PLOT(X,Y,3)
      WRITE(2)X,Y,IPU
      SCRA=SCON
      IF(NRC.EQ.3)SCRA=SCON/2
      R=SCRA*(RN(NRC+1)-.5)*CELWTH(NTP+1)/(3.84*10E03)
      X=SCALE*(R*SIN(AZMUTH(1)*RPD)+4.0)
      Y=SCALE*(R*COS(AZMUTH(1)*RPD)+4.0)
      IF(PRINT4)CALL PLOT(X,Y,2)
      WRITE(2)X,Y,IPD
      X=SCALE*(R*SIN(AZMUTH(NA)*RPD)+4.0)
      Y=SCALE*(R*COS(AZMUTH(NA)*RPD)+4.0)
      IF(PRINT4)CALL PLOT(X,Y,3)
      WRITE(2)X,Y,IPU
      X=4.0
      Y=4.0
      IF(PRINT4)CALL PLOT(X,Y,2)
      WRITE(2)X,Y,IPD
      GO TO 871
831   DO 861 K=1,NFC
      IE=ICVNT(K)
      DO 861 I=1,IE
      DO 841 L=1,NPA
841   IC(L,I,K)=IC1(L,I,K)
      DO 851 L=1,NPB
851   CI(L,I,K)=CI1(L,I,K)
861   CONTINUE
      TEMP=AZMUTH(NA)*RPD
      DELTAZ=(AZMUTH(1)-TEMP)*RPD
      AZNOW=AZMUTH(1)
      GO TO 321
```

```
C              OUTER C EVENT LOOP
C
      DO 951 IE=1,IEM
      IPK=1
      IPL=1
      IP=IDC(IE)
      IF (IP.EQ.0) GO TO 951
      JE1=0
      JE2=0
C
C              FIND B EVENTS ASSOCIATED WITH C EVENTS.
C              JEM IS NO. OF EVENTS IN PREVIOUS RADIAL.
C
      JEM=IBVNT(1)
      IF(JEM .EQ. 0) GO TO 41
      DO 31 JE=1,JEM
      IF (IC(4,IE,1).NE.IB(4,JE,1)) GO TO 31
      JE2=JE
      IF (JE1.EQ.0) JE1=JE
31    CONTINUE
C
C              FIND THRESHOLDS FOR IE EVENT
C
41    DO 51 J=1,JMXDB
51    T(J)=0
      DO 71 L=IPL,IP
      IR=IPCRNG(L,IE)
      DO 71 K=1,LDB
      IT=IABS(U(IR))-TM-K+1
      IF(IT.GE.1.AND.IT.LE.JMXDB)T(IT)=1
71    CONTINUE
      IPT=1
      DO 91 L=1,JMXDB
      IF (T(L)) 91,91,81
   81 TC(IPT,IE)=L+TM-1
      IPT=IPT+1
91    CONTINUE
      IPT=IPT-1
      IPTC(IE)=IPT
C
C              LOOP ON RANGE IN IE EVENT TO FIND CONTOUR
C
      IBGN=IC(1,IE,1)+1
      IND=IC(2,IE,1)+1
      DO 161 I=IBGN,IND
      IF (I.NE.IPCRNG(IPK,IE)) GO TO 101
      IPK=IPK+1
C
C              LOOP ON THRESHOLD
C
101   DO 131 K=1,IPT
      IF (U(I).EQ.-999) GO TO 141
      IF (IABS(U(I)).GT.TC(K,IE)) GO TO 111
      GO TO 141
111   IF (U(I-1).EQ.-999) GO TO 121
```

84

```
      SUBROUTINE PEAKD (U,LDB,TM,IPCRNG,IDC,ITY,TATR,IPB1,IPB2,IPB3,IPTB
     1,TB,IPBNT,IPCNT,T,IPC1,IPC2,IPC3,IPTC,UP,TC,JMXDB,IEMAX,KMAX,JMAX,
     2NCELL,NID,IB,IC,ICVNT,IBVNT,NPA,NFC,IPLO,NUMAX,NUP,IACT,HB)
C     ******************************************************************
C     VERSION 1.0   LEVEL 770112
C     JHW   AFGL 6600
C     DETERMINES PEAK VALUES AND THEIR ATTRIBUTES.
C     ******************************************************************
      INTEGER IPCRNG(JMAX,IEMAX),IDC(IEMAX),IPB1(JMAX,KMAX,IEMAX),IPB2(J
     1MAX,KMAX,IEMAX),IPB3(JMAX,KMAX,IEMAX),IPTB(IEMAX),TB(KMAX,IEMAX),I
     2PBNT(KMAX,IEMAX),T(JMXDB),IPC1(JMAX,KMAX,IEMAX),IPC2(JMAX,KMAX,IEM
     3AX),IPC3(JMAX,KMAX,IEMAX),IPTC(IEMAX),TC(KMAX,IEMAX),IPLO(JMAX,KMA
     4X),IB(NPA,IEMAX,NFC),IC(NPA,IEMAX,NFC),ICVNT(NFC),IBVNT(NFC),IPCNT
     5(KMAX,IEMAX),IACT(NID),HB(1),U(1)
      INTEGER W,V,VS,SV,VB,VJ,UI,VSI,H1,H2
      INTEGER TV,TSV,TM,TL,STARTR
      REAL TATR(NUMAX,NID),UP(NUP,NID)
C     ------------------------------------------------------------------
      COMMON /STORE/ AE,AA,BB,SL,CL,TV,TSV
      COMMON /STOR2/ IMX
      COMMON /INSUB/ TL(4),MT,TDW,DN,STARTR,DELTR,RN(4),SCON,CELWTH(3)
      COMMON/AZM/ AZMUTH(460),NA,ELEVAT,PRF,KEEP
      COMMON /ADATA/ IDAY,IHOUR,IMIN,ISEC,NTP,NSF,NDD,NRC
      COMMON/WORK/W(514),V(514),VS(514),SV(514),VB(514),VJ(514),UI(514),
     1VST(514),H1(514),H2(514),NCL
      COMMON /AZ2/SAZ,CAZ,DAZ,ISCANF,NEL
C     ------------------------------------------------------------------
C
C              IEM IS NO.OF EVENTS IN C RADIAL.
C              INITIALIZE AND GENERATE HC ARRAY
C
      IEM=ICVNT(1)
      LM=5+3*ITY
      LMM=LM-1
      IDX=LM+1
      NCLM=NCL-1
      LDMX=(NUMAX-2)/LM
      IF (LDB.GT.LDMX) LDB=LDMX
      NUMP=2+LM*LDB
C
C              ZERO ARRAYS
C
      DO 11 I=1,KMAX
      DO 11 J=1,JMAX
11    IPLO(J,I)=0
      DO 21 I=1,IEMAX
      IPTC(I)=0
      DO 21 K=1,KMAX
      TC(K,I)=0
      IPCNT(K,I)=0
      DO 21 J=1,JMAX
      IPC1(J,K,I)=0
      IPC2(J,K,I)=0
21    IPC3(J,K,I)=0
C
```

```
     X          2X,4H(KM),5X,5H(DBZ),6X,11H(DBZ.KM**2),1X,7H(M/SEC),1X,
     X7H(M/SEC),1X,11H(M/SEC)**2))
      TZ=TZ/10E05
      WRITE(6,717)I,AVZ,TZ,VE,VN,VER,DEL
  717 FORMAT(I5,6X,F5.1,7X,F9.1,2X,F6.1,2X,F6.1,2X,F10.1,1X,E15.5)
      WRITE(6,881)
  881 FORMAT(1X,8(*------------*))
921   CONTINUE
      ID1=-999
      WRITE(2)XBAR,YBAR,ID1
      CALL PAGE
      WRITE(6,932)
932   FORMAT(1H ,* PEAK DETECTED CELL ATTRIBUTES*)
      WRITE(6,714)
  714 FORMAT(41X,7HAVERAGE,3X,7HAVERAGE/30X,8HLOCATION,3X,6HRADIAL,2X,
     X10HTANGENTIAL,1X,10HTANGENTIAL/6X,12HREFLECTIVITY,3X,4HAREA,3X,
     X4HEAST,2X,5HNORTH,3X,5HSHEAR,4X,5HSHEAR,6X,5HSHEAR/2X,2HID,5X,
     X5H(DBZ),5X,7H(KM**2),2X,4H(KM),3X, 4H(KM),8H(M/S/KM),3X,
     X8H(M/S/KM),3X,8H(M/S/KM))
      DO 933 N=1,NCEL
      IF(UP(1,N).LE.0..OR.UP(2,N).EQ.0.)GO TO 933
      UP(3,N)=UP(3,N)/UP(2,N)/10E02
      UP(4,N)=UP(4,N)/UP(2,N)/10E02
      UP(2,N)=UP(2,N)/UP(1,N)
      UP(5,N)=UP(5,N)/UP(1,N)*10E02
      UP(6,N)=UP(6,N)/UP(1,N)
      UP(1,N)=UP(1,N)*DELR/1.E06
      WRITE(6,718)N,UP(2,N),UP(1,N),UP(3,N),UP(4,N),UP(5,N),UP(6,N),
     XUP(7,N)
  718 FORMAT(I4,5X,F5.1,6X,F6.1,1X,F6.1,1X,F6.1,1X,F7.2,4X,F6.2,4X,F7.2)
933   CONTINUE
      CALL PAGE
      WRITE(6,942)
  942 FORMAT(1H ,* TANGENTIAL SHEAR MAXIMA ATTRIBUTES*)
      WRITE(6,715)
  715 FORMAT(25X,8HLOCATION/7X,5HSHEAR,4X,4HAREA,3X,4HEAST,2X,5HNORTH/
     X2HID,
     X1X,8H(M/S/KM),1X,7H(KM**2),2X,4H(KM),3X,4H(KM))
      DO 943 N=1,NVCEL
      IF(UV(1,N).LE.0..OR.UV(2,N).EQ.0.)GO TO 943
      UV(4,N)=UV(4,N)/UV(2,N)
      UV(3,N)=UV(3,N)/UV(2,N)
      UV(2,N)=UV(2,N)/UV(1,N)
      UV(1,N)=UV(1,N)*DELR/1.E06
      WRITE(6,719)N,UV(2,N),UV(1,N),UV(3,N),UV(4,N)
  719 FORMAT(I4,1X,F7.1,3X,F6.1,1X,F6.1,1X,F6.1)
  943 CONTINUE
      WRITE(6,950)IDD
  950 FORMAT(1H0,10HTOTAL IDD=,I6)
      ISCANF=0
      RETURN
      END
```

```
871   DELR=SCON*CELWTH(NTP+1)
      IPU=-999
      WRITE(2)X,Y,IPU
      CALL PAGE
      WRITE(6,872)
872   FORMAT(1H ,* FIXED CONTOUR ATTRIBUTES*)
      WRITE(6,712)
  712 FORMAT(28X,7HAVERAGE,5X,8HLOCATION,4X,5HTOTAL,3X,7HAVERAGE/
     X5X,9HTHRESHOLD,5X,4HAREA,2X,12HREFLECTIVITY,1X,4HEAST,2X,
     X5HNORTH,2X,6HPRECIP,4X,6HPRECIP/2X,2HID,4X,
     X5H(DBZ),4X,7H(KM**2),4X,5H(DBZ),5X,4H(KM),3X,4H(KM),1X,9H(TONS/HR)
     X1X,7H(MM/HR))
      DO 931 K=1,NFC
      JDD=KDD(K)
      DO 931 J=1,JDD
      IEDGE=0
      IF (ATR(IAT,J,K).EQ.0.0) GO TO 931
      IF (ATR(IAT,J,K).LT.0.) IEDGE=1
      ID1=J
      ABAR=DELR*ATR(1,J,K)
      IF(ABAR.LE.0.)GO TO 931
      ZBAR=ATR(2,J,K)*DELR/ABAR
      XBAR=ATR(3,J,K)*DELR/ABAR/ZBAR
      YBAR=ATR(4,J,K)*DELR/ABAR/ZBAR
      ABAR=ABAR/1000**2
      IF(K.GT.1)WRITE(6,720)ID1,TL(K),ABAR,ZBAR,XBAR,YBAR
  720 FORMAT(1X,I3,5X,I2,4X,F9.2,4X,F5.1,4X,2F6.1)
      IF (K.GT.1) GO TO 931
      TPREC=DSI(J)*DELR
      AVPREC=TPREC/(ABAR*1000)
      TPREC=TPREC/10E05
      WRITE(6,716)ID1,TL(K),ABAR,ZBAR,XBAR,YBAR,TPREC,AVPREC
  716 FORMAT(1X,I3,5X,I2,4X,F9.2,4X,F5.1,4X,F6.1,1X,F6.1,1X,F7.2,2X,
     XF6.2/)
      YBAR=YBAR/(3.84*10E03)+4.0
      XBAR=XBAR/(3.84*10E03)+4.0
      WRITE(2)XBAR,YBAR,ID1
931   CONTINUE
      DO 921 I=1,NNE
      IF(ZH(NZP,I,J).EQ.0)GO TO 921
      TZ=DELR*ZH(11,I,J)
      AVZ=ZH(11,I,J)/ZH(12,I,J)
C               COMPUTE AVG WIND SPEED AND DIR.
      DEL=ZH(5,I,J)*ZH(6,I,J)-ZH(7,I,J)*ZH(7,I,J)
      IF (DEL.EQ.0.) GO TO 921
      VN=(ZH(4,I,J)*ZH(5,I,J)-ZH(3,I,J)*ZH(7,I,J))/DEL
      VE=(ZH(6,I,J)*ZH(3,I,J)-ZH(7,I,J)*ZH(4,I,J))/DEL
      VER=(ZH(2,I,J)+VN*VN*ZH(6,I,J)+VE*VE*ZH(5,I,J)+2.0*VN*VE*ZH(7,I,J)
     1-2.0*VN*ZH(4,I,J)-2.0*VE*ZH(3,I,J))/ZH(10,I,J)
      VF=ZH(5,I,J)/ZH(10,I,J)-(ZH(8,I,J)/ZH(10,I,J))
      VC=ZH(6,I,J)/ZH(10,I,J)-(ZH(9,I,J)/ZH(10,I,J))**2
      WRITE(6,713)
  713 FORMAT(1H0,10X,7HAVERAGE,6X,5HTOTAL,5X,7HAVERAGE,1X,7HAVERAGE,2X,
     X8HVELOCITY/1X,6HHEIGHT,1X,12HREFLECTIVITY,1X,12HREFLECTIVITY,4X,
     X1HU,7X,1HV,5X,8HVARIANCE,14X,3HDEL/
```

```
      NAME=12
      WRITE(6,9909)NAME,NPCEL
C
C                ASSOCIATE CELLS ON B RADIAL, TOP DOWN
C
193   MPK=0
      NAME=11
      WRITE(6,9909)NAME,NPK
9909  FORMAT(5X,I2,10X,I5)
      IF(NA.EQ.1)GO TO 361
      TATM=0.
      IHB=IPC1(IPE,KC,IE)+1
      IHD=IPC2(IPE,KC,IE)
      DO 194 I=IHB,IHD
      IF(HB(I).EQ.-999)GO TO 194
      IF(IABS(HB(I)).GT.TC(KC,IE)+LDB)GO TO 934
194   CONTINUE
      IF (JE2.EQ.0) GO TO 361
      DO 261 JE=JE1,JE2
      IF  (IB(2,JE,1).LT.IPC1(IPE,KC,IE)) GO TO 261
      IF  (IB(1,JE,1).GT.IPC2(IPE,KC,IE)) GO TO 361
C
C                JE EVENT ON B RADIAL IS ASSOCIATED
C
271   IPB=IPTB(JE)
      DO 291 LB=1,IPB
      KB=IPB-LB+1
      NP1=IPBNT(KB,JE)
      DO 281 JPE=1,NP1
      IF  (IPB2(JPE,KB,JE).LT.IPC1(IPE,KC,IE)) GO TO 281
      IF  (IPB1(JPE,KB,JE).GT.IPC2(IPE,KC,IE)) GO TO 361
      LPCEL=IPB3(JPE,KB,JE)
      WRITE(6,2729)JPE,IPE,KB,KC,JE,IE,LPCEL,MPK
 2729 FORMAT(2X,8I10)
      IF(LPCEL.EQ.0)GO TO 281
      TATM=AMAX1(TATM,TATR(1,LPCEL))
      IF(TATM.EQ.TATR(1,LPCEL))MPK=LPCEL
281   CONTINUE
291   CONTINUE
261   CONTINUE
      IF(MPK.EQ.0)GO TO 361
      IF(ABS(TATR(1,MPK)).GT.TC(KC,IE)+LDB)MPK=-MPK
      GO TO 361
  934 MPK=-(NID+1)
C
C                HAVE B COMPARE WITHIN RANGE
C
361   CONTINUE
      NAME=21
      WRITE(6,9909)NAME,MPK
      IF(MPK.EQ.0.AND.NPK.EQ.0)GO TO 631
C
C                MPK=0.AND.NPK=0 - NO COMPARE
C                MPK=0.AND.NPK.NE.0 - NO B COMPARE
C                NPK=0.AND.MPK.NE.0 - B COMPARE
```

```
      IF (IABS(U(I-1)).LE.TC(K,IE)) GO TO 121
      GO TO 131
C
C                START RANGE FOR SEGMENT (CONTOUR)
C
121   IPCNT(K,IE)=IPCNT(K,IE)+1
      IPE=IPCNT(K,IE)
      IPC1(IPE,K,IE)=I-1
      IPLO(IPE,K)=IPK-1
131   CONTINUE
      GO TO 161
C
C                END RANGE FOR SEGMENT
C
141   DO 151 KL=K,IPT
      IF (U(I-1).EQ.-999) GO TO 161
      IF (IABS(U(I-1)).LE.TC(KL,IE)) GO TO 161
      IPE=IPCNT(KL,IE)
      IPC2(IPE,KL,IE)=I-1
151   CONTINUE
161   CONTINUE
      DO 181 K=1,IPT
      IPE=IPCNT(K,IE)
      DO 181 I=1,IPE
      WRITE(6,171)IE,I,K,IPC1(I,K,IE),IPC2(I,K,IE),IPCNT(K,IE),IPLD(I,K)
     1,TC(K,IE)
  171 FORMAT(1H ,3I3,5I10)
181   CONTINUE
C
C                ASSOCIATE CELLS   LOOP ON THRESHOLD HIGHEST TO LOWEST
C
940   DO 941 LC=1,IPT
      KC=IPT-LC+1
      NPC=IPCNT(KC,IE)
C                LOOP ON SEGMENTS
      DO 941 IPE=1,NPC
      K=KC+1
      NPK=0
      TATM=0.
      IF (K.GT.IPT) GO TO 193
      LPE=IPCNT(K,IE)
  192 DO 191 L=1,LPE
      IF (IPC2(L,K,IE).LT.IPC1(IPE,KC,IE)) GO TO 191
      IF(IPC1(L,K,IE).GT.IPC2(IPE,KC,IE))GO TO 193
      NPCEL=IPC3(L,K,IE)
      IF (NPCEL.EQ.0) GO TO 932
      TATM=AMAX1(TATM,TATR(1,NPCEL))
      IF(TATM.EQ.TATR(1,NPCEL))NPK=NPCEL
C
C                NPCEL IS FOR NEXT HIGHER (ENCLOSED) THRESHOLD ON C RADIAL
C
  231 IF (ABS(TATR(1,NPCEL)).GT.(TC(KC,IE)+LDB   ))GO TO 932
191   CONTINUE
      GO TO 193
932   NPK=-1
```

```
C                HIGHEST THIS RADIAL
C
      IF(MPK.EQ.0.AND.NPK.LT.0)GO TO 931
      IF(MPK.NE.0)GO TO 421
C
C                NO PRIOR RADIAL FOR COMPARISON, INCREMENT NPCEL
C
381   NPCEL=NPK
      IF(NA.EQ.1)GO TO 359
      DO 352 I=IHB,IHD
      IF(HB(I).EQ.-999)GO TO 352
      IF(IABS(HB(I)).GE.TC(KC,IE))GO TO 931
352   CONTINUE
  359 INDX=TATR(1,NPCEL)-TC(KC,IE)-1
391   IF (INDX.GE.LDB) GO TO 931
      IPC3(IPE,KC,IE)=NPCEL
      IN=1+INDX*LM
      INX=IDX+INDX*LM
      IF(NA.EQ.1)GO TO 419
      IST=IPC1(IPE,KC,IE)+1
      ISP=IPC2(IPE,KC,IE)
      DO 411 I=IST,ISP
      R=SCON*(FLOAT(I-1)-.5)*CELWTH(NTP+1)
      TATR(IN+1,NPCEL)=TATR(IN+1,NPCEL)+DAZ*R
      TATR(IN+2,NPCEL)=TATR(IN+2,NPCEL)+DAZ*R*U(I)
      TATR(IN+3,NPCEL)=TATR(IN+3,NPCEL)+DAZ*SAZ*R*R*U(I)
      TATR(IN+4,NPCEL)=TATR(IN+4,NPCEL)+DAZ*CAZ*R*R*U(I)
      IF (ITY.NE.1) GO TO 411
      IF (V(I).EQ.-999.OR.V(I-1).EQ.-999) GO TO 401
      TATR(IN+5,NPCEL)=TATR(IN+5,NPCEL)+DAZ*R*(V(I)-V(I-1))
401   IF (VS(I).EQ.-999) GO TO 411
      TATR(IN+6,NPCEL)=TATR(IN+6,NPCEL)+R*VS(I)
      TATR(IN+7,NPCEL)=AMAX1(TATR(IN+7,NPCEL),FLOAT(IABS(VS(I))))
411   CONTINUE
419   TATR(INX,NPCEL)=SIGN(FLOAT(NA),TATR(INX,NPCEL))
      IF(IST.EQ.2.OR.ISP.EQ.IMX)TATR(INX,NPCEL)=SIGN(TATR(INX,NPCEL),-1.
     10)
      NAME=31
      WRITE(6,9909)NAME,INDX
      WRITE(6,1071)NPCEL,(TATR(KZ,NPCEL),KZ=1,NUMP)
C
C                COMBINE LPCEL WITH NPCEL AT THIS LEVEL
C
366   DO 365 L=1,LPE
      IF(IPC2(L,K,IE).LT.IPC1(IPE,KC,IE))GO TO 365
      IF(IPC1(L,K,IE).GT.IPC2(IPE,KC,IE))GO TO 931
      LPCEL=IPC3(L,K,IE)
341   IF(LPCEL.EQ.0)GO TO 931
      IF(TATR(IDX,LPCEL).EQ.0.)GO TO 365
351   IF(NPCEL.EQ.LPCEL)GO TO 365
      INDX=TATR(1,NPCEL)-TC(KC,IE)-1
      INX=IDX+INDX*LM
      IF(INX.GT.NUMP)GO TO 365
      TATR(INX,LPCEL)=0.
      TATR(2+INDX*LM,LPCEL)=NPCEL
```

```
      IND=LDB-INDX
      DO 483 I=1,IND
      DO 483 J=1,LM
      IN=1+J+(LDB-I)*LM
      IM=1+J+(IND-I)*LM
  483 TATR(IN,LPCEL)=TATR(IM,LPCEL)
      IND=INDX*LM+1
482   DO 484 I=INS,IND
  484 TATR(I,LPCEL)=0.
  488 IN=0
      IPC3(IPE,KC,IE)=LPCEL
      NAME=61
      WRITE(6,9909)NAME,INDX
      GO TO 512
  485 DO 486 I=1,NID
      IF(IACT(I).EQ.0)GO TO 487
  486 CONTINUE
      WRITE(6,644)
      GO TO 931
  487 LPCEL=I
      IACT(I)=1
      TATR(1,LPCEL)=TC(KC,IE)+1
      TATR(NUMP,LPCEL)=IC(NPA,IE,1)
      GO TO 488
  422 LPCEL=IABS(MPK)
      IF(LPCEL.GT.NID)GO TO 931
      DO 441 JE=JE1,JE2
      IF (IB(2,JE,1).LT.IPC1(IPE,KC,IE)) GO TO 441
      IF (IB(1,JE,1).GT.IPC2(IPE,KC,IE)) GO TO 632
      IPB=IPTB(JE)
      DO 471 LB=1,IPB
      KB=IPB-LB+1
      MPB=IPBNT(KB,JE)
      DO 461 JPE=1,MPB
      IF (IPB2(JPE,KB,JE).LT.IPC1(IPE,KC,IE)) GO TO 461
      IF (IPB1(JPE,KB,JE).GT.IPC2(IPE,KC,IE)) GO TO 632
      NPCEL=IPB3(JPE,KB,JE)
      IF (NPCEL.LE.0) GO TO 461
      IF(LPCEL.EQ.NPCEL)GO TO 461
      IF(TB(KB,JE).GT.TC(KC,IE))GO TO 461
C
C               COMBINE AT TB=TC LEVEL AND BELOW
C
502   INDX=TATR(1,NPCEL)-TB(KB,JE)
      NAME=71
      WRITE(6,9909)NAME,INDX
      IF(INDX.GE.LDB)GO TO 461
      IMDX=TATR(1,LPCEL)-TB(KB,JE)
      NAME=81
      WRITE(6,9909)NAME,IMDX
      IF(IMDX.LT.LDB)GO TO 861
851   DO 852 J=1,NUMP
852   TATR(J,NPCEL)=0.
      IACT(NPCEL)=0
      NAME=101
```

```
      WRITE(6,9909)NAME,NPCEL
      GO TO 461
  861 IND=INDX-LDB
      DO 891 N=1,IND
      LD=1+(LDB-N)*LM
      ND=1+(INDX-N)*LM
      DO 891 I=1,LM
      IF (I.GE.LM) GO TO 881
      IF (I.GE.8) GO TO 871
      TATR(LD+I,LPCEL)=TATR(ND+I,NPCEL)+TATR(LD+I,LPCEL)
      TATR(ND+I,NPCEL)=0.
      GO TO 891
871   TATR(LD+I,LPCEL)=AMAX1(TATR(ND+I,NPCEL),TATR(LD+I,LPCEL))
      TATR(ND+I,NPCEL)=0.
      GO TO 891
  881 TATR(ND,I)=LPCEL
891   CONTINUE
461   CONTINUE
471   CONTINUE
441   CONTINUE
632   IF(NPK.LE.0)GO TO 931
      NPCEL=LPCEL
      GO TO 366
C
C                   UNASSOCIATED
C
  631 IF(NA.EQ.1)GO TO 639
      DO 641 I=IHB,IHD
      IF (HB(I).EQ.-999) GO TO 641
      IF (IABS(HB(I)).GE.TC(KC,IE))GO TO 931
641   CONTINUE
  639 DO 642 J=1,NID
      IF(IACT(J).EQ.0)GO TO 643
642   CONTINUE
      WRITE(6,644)
644   FORMAT(5X,* TOO MANY CELLS*)
      GO TO 931
643   NPCEL=J
      IACT(J)=1
661   IPC3(IPE,KC,IE)=NPCEL
      IPK=IPLD(IPE,KC)
      IR=IPCRNG(IPK,IE)
      IN1=LM+1
      IN=(LDB-1)*LM+IN1
      DO 671 I=IN1,IN
      TATR(I,NPCEL)=0.0
671   CONTINUE
591   TATR(1,NPCEL)=IABS(U(IR))
      TATR(NUMP,NPCEL)=IC(NPA,IE,1)
      IF(NA.EQ.1)GO TO 939
      IST=IPC1(IPE,KC,IE)+1
      ISP=IPC2(IPE,KC,IE)
      DO 621 I=IST,ISP
      R=SCON*(FLOAT(I-1)-.5)*CELWTH(NTP+1)
      TATR(2,NPCEL)=DAZ*R+TATR(2,NPCEL)
```

92

```
      TATR(3,NPCEL)=DAZ*R*U(I)+TATR(3,NPCEL)
      TATR(4,NPCEL)=DAZ*SAZ*R*R*U(I)+TATR(4,NPCEL)
      TATR(5,NPCEL)=DAZ*CAZ*R*R*U(I)+TATR(5,NPCEL)
      IF (ITY.NE.1) GO TO 621
      IF (V(I).EQ.-999.OR.V(I-1).EQ.-999) GO TO 601
      TATR(6,NPCEL)=DAZ*R*(V(I)-V(I-1))+TATR(6,NPCEL)
601   IF (VS(I).EQ.-999) GO TO 621
      TATR(7,NPCEL)=DAZ*R*VS(I)+TATR(7,NPCEL)
      TATR(8,NPCEL)=AMAX1(TATR(8,NPCEL),FLOAT(IABS(VS(I))))
621   CONTINUE
  939 TATR(IDX,NPCEL)=NA
      IF(IST.EQ.2.OR.ISP.EQ.IMX)TATR(IDX,NPCEL)=-TATR(IDX,NPCEL)
      WRITE(6,1071)NPCEL,(TATR(KZ,NPCEL),KZ=1,NUMP)
931   CONTINUE
941   CONTINUE
951   CONTINUE
      IF(NA.EQ.1)GO TO 1031
C
C               END OF ASSOCIATION LOOPS
C
      ID2=1+(LDB-1)*LM
      LDX=1+LDB*LM
      DO 991 I=1,NID
      IF(IACT(I).EQ.0)GO TO 991
      IF(TATR(1,I).GT.0..AND.TATR(2,I).GT.0.)GO TO 961
      GO TO 991
961   IF(TATR(LDX,I).LE.0..OR.TATR(ID2+1,I).LE.0.)GO TO 991
      IF (TATR(LDX,I).LT.NA.OR.ISCANF.EQ.1)GO TO 971
      GO TO 991
  971 DO 981 J=1,LMM
      UP(J,NCELL)=TATR(ID2+J,I)
981   CONTINUE
      UP(LM,NCELL)=TATR(NUMP,I)
      NAME=101
      WRITE(6,9909)NAME,I
      WRITE(6,1071)I,(TATR(K,I),K=1,NUMP)
      WRITE(6,9910)NCELL,(UP(K,NCELL),K=1,LM)
9910  FORMAT(1X,I2,12X,8F13.2)
      NCELL=NCELL+1
      DO 982 J=1,NUMP
982   TATR(J,I)=0.
      IACT(I)=0
991   CONTINUE
1031  DO 1041 I=1,IEMAX
      IPTB(I)=IPTC(I)
      DO 1041 K=1,KMAX
      TB(K,I)=TC(K,I)
      IPBNT(K,I)=IPCNT(K,I)
      DO 1041 J=1,JMAX
      IPB1(J,K,I)=IPC1(J,K,I)
      IPB2(J,K,I)=IPC2(J,K,I)
      IPB3(J,K,I)=IPC3(J,K,I)
1041  CONTINUE
      DO 1 I=2,NCLM
      MH=-999
```

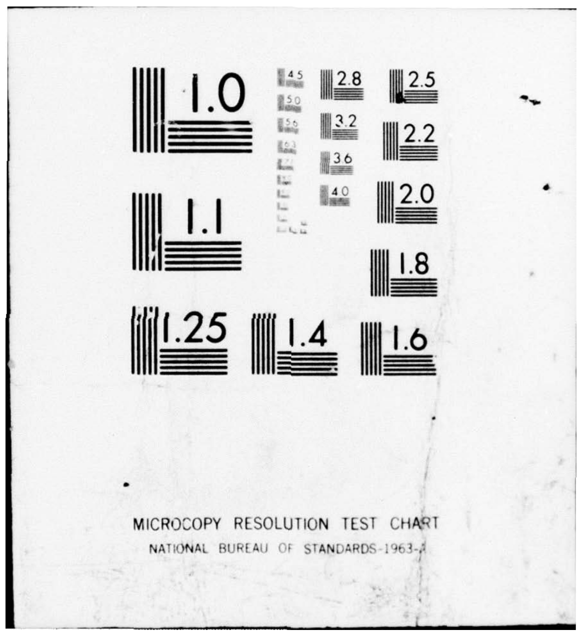
```
      IF (U(I-1).NE.-999) MH=IABS(U(I-1))
      IF (U(I).NE.-999) MH=MAX0(MH,IABS(U(I)))
      IF (U(I+1).NE.-999) MH=MAX0(MH,IABS(U(I-1)))
1     HB(I)=MH
      N=1
      WRITE (6,1061) N
1061  FORMAT (I6)
      DO 1081 I=1,NID
      IF(IACT(I).EQ.0)GO TO 1081
      WRITE(6,1071) I,(TATR(K,I),K=1,NUMP)
1071  FORMAT(1X,I2,3X,9F13.2,/(19X,8F13.2))
1081  CONTINUE
      N=2
      WRITE(6,1061)N
1082  DO 1101 IE=1,IEM
      IPT=IPTB(IE)
      DO 1101 K=1,IPT
      IPE=IPBNT(K,IE)
      DO 1101 I=1,IPE
      ITATR=0
      TATRX=0.
      IPX=IPB3(I,K,IE)
      IF(IPX.GT.0)TATRX=TATR(1,IPX)
      IF(IPX.GT.0)ITATR=TATR(IDX,IPX)
      WRITE(6,1091)I,K,IE,IPB1(I,K,IE),IPB2(I,K,IE),IPB3(I,K,IE),TB(K,
     1IE),TATRX,ITATR
1091  FORMAT(1H ,3I5,4I8,E15.3,I8)
1101  CONTINUE
      RETURN
      END
```

94

AD-A052 535 ENVIRONMENTAL RESEARCH AND TECHNOLOGY INC CONCORD MASS F/G 4/2
PARAMETERIZATION OF WEATHER RADAR DATA FOR USE IN THE PREDICTIO--ETC(U)
MAR 77 R K CRANE F19628-76-C-0264
UNCLASSIFIED ERT-P-2095 AFGL-TR-77-0216 NL

2 OF 2
AD
A052535

END
DATE
FILMED
5-78
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
      SUBROUTINE PRN1
C     ******************************************************************
C     PRINTS OUT UNPACKED DATA (INTEGER FORMAT).
C     VERSION 1.0   LEVEL 760920
C     JHW  CDC 6600  AFGL    P2095
C     ******************************************************************
      COMMON/A1024/MVP(3,1024)
      COMMON/AZM/AZMUTH(460),NA,ELEVAT,PRF,KEEP
      COMMON/ADATA/IDAY,IHOUR,IMIN,ISEC,NTP,NSF,NDD,NRC
C     ------------------------------------------------------------------
      CALL PAGE
      WRITE(6,100)IDAY,IHOUR,IMIN,ISEC,NTP,NSF,NDD,NRC,PRF,AZMUTH(NA),
     X ELEVAT
  100 FORMAT(38H  UNPACKED RADAR DATA (INTEGER VALUES)/2X,
     X*DAY HR MN SC  CELLWIDTH SUBFRAME DUMP FREQ #CELLS   PRF   AZIMUTH
     X  ELEVATION*/I5,3I3,9X,I2,7X,I2,8X,I2,I7,F6.0,F10.1,3X,F9.1//4X,
     X1HI,2X,8(14H  MEAN VAR PWR)/)
      KK=KEEP
      NN=KEEP+7
      DO 10 N=1,32
      WRITE(6,101)KK,((MVP(I,J),I=1,3),J=KK,NN)
  101 FORMAT(I5,2X,8(I6,2I4))
      KK=KK+8
      NN=NN+8
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRN3(MODE,W)
C     ************************************************************************
C     PRINTS BSCAN MAPS OF COMPUTED AND CODED DBZ AND VELOCITY.
C     VERSION 1.0  LEVEL 761129
C     JHW  CDC 6600  AFGL
C     ************************************************************************
      INTEGER TL,STARTR,W
      LOGICAL PRINT1,PRINT2,PRINT3,PRINT4,CONTRZ,CONTRV
C     ------------------------------------------------------------------------
      DIMENSION IC(64),W(1)
      COMMON/PARM/PRINT1,PRINT2,PRINT3,PRINT4,ICODES(36),A1,B1,A2,B2,
     X CONTRZ,CONTRV,NFILE,NREC,NUMR
      COMMON/A1024/ MVP(3,1024)
      COMMON/AZM/ AZMUTH(460),NA,ELEVAT,PRF,KEEP
      COMMON/ADATA/IDAY,IHOUR,IMIN,ISEC,NTP,NSF,NDD,NRC
C     ------------------------------------------------------------------------
      NCOL=(NRC+1)*256
      INT=NCOL/64
      IF(MODE.EQ.1)CALL COMPZ
      I=1
      L=1
    3 IV=0
      IP=0
      DO 10 N=1,INT
      L=L+1
      IV=IV+W(L)
   10 IP=IP+1
      IV=IV/IP
      IY=A1*IV + B1
      IF(IY.GT.36)IY=36
      IF(IY.LE.0)IY=1
      IC(I)=ICODES(IY)
      I=I+1
      IF(L.LT.NCOL)GO TO 3
      WRITE(6,100)AZMUTH(NA),ELEVAT,IDAY,IHOUR,IMIN,ISEC,IC,PRF
  100 FORMAT(1X,F5.1,F6.1,I4,1X,2I2,I3,5X,64A1,3X,F7.1)
      RETURN
      END
```

96

```
      SUBROUTINE PAGE
C     ************************************************************************
C     PRINTS PAGE HEADER AND KEEPS TRACK OF LINE COUNT
C     VERSION 1.0  LEVEL 711122
C     ************************************************************************
      INTEGER ICODE,IRUN,NPAGE
      REAL TITLE(6)
      COMMON /HEAD/ TITLE,ICODE,VERS,LEVEL,DAT, IRUN,NPAGE,NLOG
      COMMON/LINUM/LINE
C     ------------------------------------------------------------------------
      LINE=4
      NPAGE=NPAGE+1
      WRITE (6,2030) ICODE,IRUN,TITLE,VERS,LEVEL,DAT, NPAGE
 2030 FORMAT(*1*,I3,I6,5X,6A8,* VERSION *,F5.1,*  (*,I6,*)*,11X,
     X   A10,10X,*PAGE *,I3/1X,127(*-*))
      RETURN
      END
```

```
      SUBROUTINE LINES(N),RETURNS(A)
C     ******************************************************************
C     VERSION 1.0   LEVEL 760921
C     ******************************************************************
      REAL TITLE(6)
      INTEGER ICODE,IRUN,NPAGE,LCT
      COMMON /HEAD/ TITLE,ICODE,VERS,LEVEL,DATE,IRUN,NPAGE,NLOG
      COMMON/LINUM/LINE
      DATA LCT/61/
C     ------------------------------------------------------------------
      LINE=LINE+N
      IF(LINE.LT.LCT) RETURN
      LINE=N+4
   30 NPAGE=NPAGE+1
      WRITE(6,2030) ICODE,IRUN,TITLE,VERS,LEVEL,DATE,NPAGE
 2030 FORMAT(*1*,I3,I6,5X,6A8,* VERSION *,F5.1,*  (*,I6,*)*,11X,
     X   A10,10X,*PAGE *,I3/1X,127(*=*))
      RETURN A
      END
```

98

```
      SUBROUTINE ERRX(N,NAME)
C     ******************************************************************
C     IBM 360                 E.REIFENSTEIN                 FORTRAN IV
C     VERSION 2    LEVEL 720421
C     ******************************************************************
      INTEGER N
      REAL NAME
C     ------------------------------------------------------------------
      WRITE(6,6000) N,NAME
 6000 FORMAT(*0EXECUTION TERMINATED DUE TO ERROR NO. *,I4,* IN *,A6)
      STOP
      END
```

```
      SUBROUTINE ERRM(N,NAME)
C     ************************************************************************
C     VERSION 1.0   LEVEL 760921
C     ************************************************************************
      INTEGER N
      REAL NAME
C     ------------------------------------------------------------------------
      WRITE(6,6100)   N,NAME
 6100 FORMAT(*0ERROR NO. *,I4,* IN *,A8/)
      RETURN
      END
```

```
      SUBROUTINE INE(IC)
C     ******************************************************************
C     IBM 360                 E.REIFENSTEIN                   FORTRAN IV
C     VERSION 1        LEVEL 720602
C     READS AND PRINTS COMMENTS CARDS
C     ******************************************************************
      REAL NAME
      INTEGER IFORM,IF(3),COM(13),BLANK
      DATA IF/1H ,1H0,1H1/,NAME/3HINE/,BLANK/1H /
C     ------------------------------------------------------------------
   10 READ(IC,5010)   IFORM,COM,JF
 5010 FORMAT(14X,A1,5X,12A4,A2,A2)
      DO 20   I=1,3
      IF(IFORM.EQ.IF(I))   GO TO (30,30,40),I
   20 CONTINUE
      CALL ERRX(20,NAME)
   30 CALL LINES(I),RETURNS(32)
   32 WRITE(6,6032)   IF(I),COM
 6032 FORMAT(A1,T21,12A4,A2)
      GO TO 50
   40 CALL PAGE
      I=2
      GO TO 30
   50 IF(JF.NE.BLANK)   GO TO 10
      RETURN
      END
```

```
      SUBROUTINE DAY
C     ******************************************************************
C     VERSION 1.0   LEVEL 760921
C     ******************************************************************
      REAL TITLE(6)
      COMMON /HEAD/ TITLE,ICODE,VERS,LEVEL,DAT,IRUN,NPAGE,NLOG
C     ------------------------------------------------------------------
      DAT = DATE(D)
      RETURN
      END
```

102

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-78